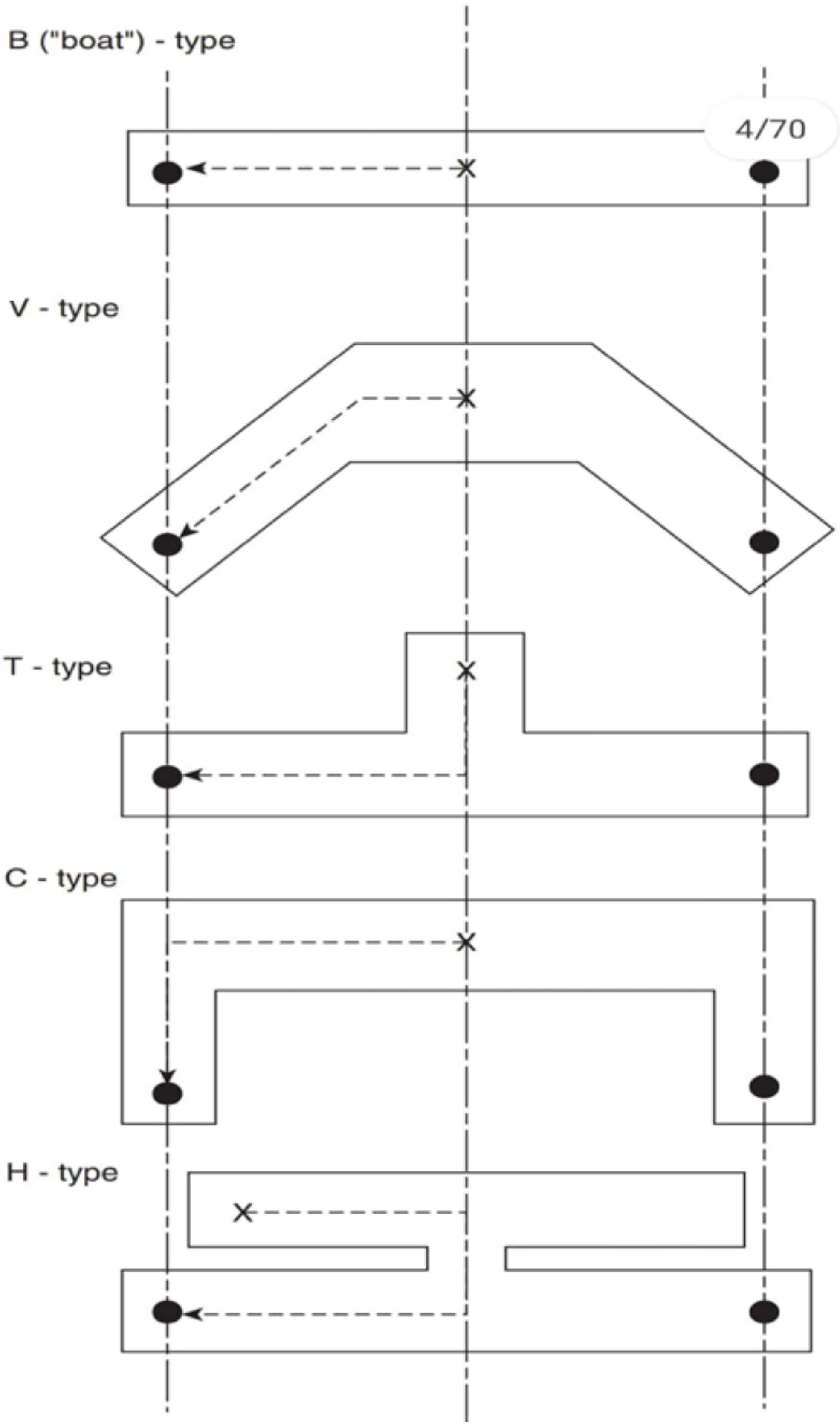
Tundish design

The tundish design fundamentals is based on the idea of steady-state operation rather than transitional, or nonsteady-state operations. The primary functions of the tundish is to act as a buffer reservoir between the ladle and the mold but nowadays its functions have been broadly diversified which includes effective inclusion removal, thermal equilibration, chemical homogenization, and to provide a nonreactive environment and as a container vessel that supports the kinetics and thermodynamics of these functions.
Thus designing of tundish is critical in order for the tundish to be used as an inclusion, temperature and chemistry refiner and serve as the a noncontaminator vessel .

The tundish design has to be constructed keeping in mind the fundamental and metallurgical need of the steel makers and these are some of the points to ponder upon:

- The product which is to be casted.
- Matching the number of strands.
- Cleanliness improvements.
- Lining thickness and design.
- Need for latest tundish furniture.
- Tundish fly capability and the need for extended continuous casting.
- Yield losses.

The need for improvement in steel cleanliness remains the key and of outmost priority. Thus design has to be constructed keeping in mind the cleanliness essentials of tundish. Tundish size is defined by its wall angles and the length, height and width dimensions, while geometry is often determined by the number of strands to be cast, as well as by available shop floor layout constraints.
Examples of various tundish shapes are boat type, T-type, V- type, C-type and H- type.



Slab caster Tundish Designs

The trough-shaped tundish, commonly known as a boat- or bathtub-shape, is probably the most frequently encountered design.
Variations of the rectangular-base trough include coffin-shaped and flared-trough designs. The trough shape is one of the common design in single- and two-strand slab casters, and can also be found on many bloom and billet casters.

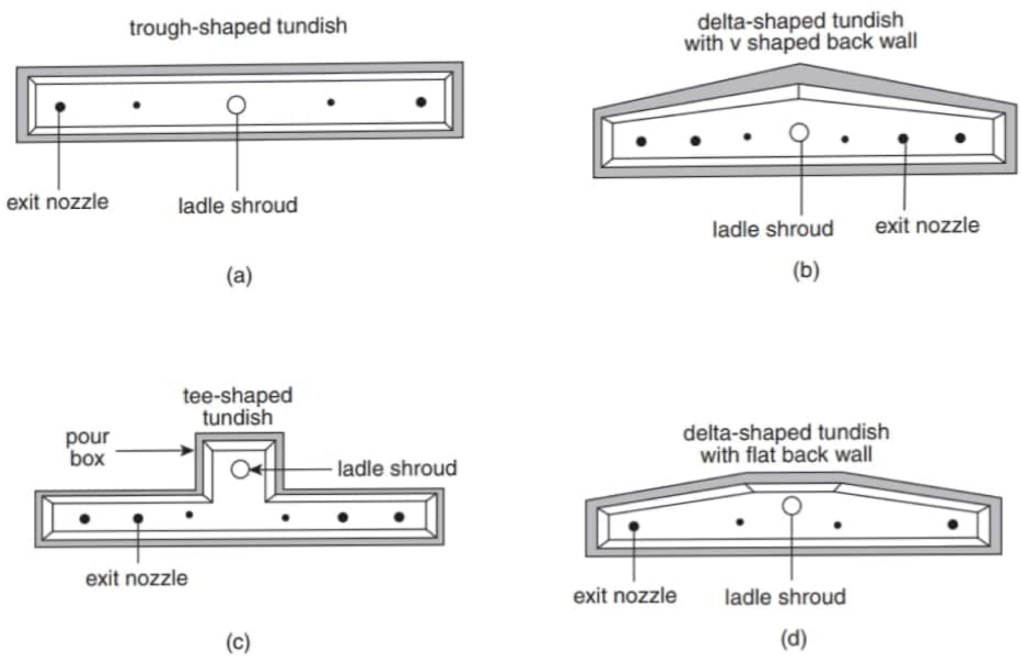
The V-shaped tundish has a huge pouring box and a more circuitous path to the strand as compared to a conventional trough tundish.
The C-tundish is a modified version of the boat- and V tundishes shapes taken into combination.
The T-shaped tundish is employed on bloom/billet machines, and is essentially a modified trough with a separate and contain a central pouring box . The design inhibits the turbulence in the pouring box to spread to the the inner strands and ensures a full metal head for delivery to all strands eliminating the chances of strand failures.

Numerical investigation of Boat shape, T-shape and V-shape tundishes have been carried out by solving the Navier-Stokes equation together with standard k-ε turbulence model. Mixing phenomena has been studied numerically by solving the species concentration equation. The residence time distribution (RTD) curves have been used to analyze the intermixing amount inside the different shapes of tundishes. Velocity vectors of molten steel have been predicted
and comparative study of fluid flow and intermixing have been performed for different cases. Numerical model has been validated with the experimental result obtained from water model setup of the continuous casting tundish. Studies have shown that shape of tundish play significant role on intermixing amount. V-shape tundish has been found to have least amount of intermixing as compared to that of Boat and T-shape tundish of steel during ladle change over.

Fluid flow in tundish shows that turbulence in the molten steel flow increases the intermix amount. Effect of tundish shape and outlet position have an significant effect on production of steel of different grade specifications as well as reduce short-circuiting issues. More modern bloom and billet casters have relied on the delta-shape with either a V or flat wall near the ladle stream impact to synchronize flow to all strands.

Compared to the rectangular trough shapes, the trapezoidal shaped boxes have the advantage of simpler mold access and render more protection for the strand operators and stand equipment, as the mold panels are generally farther moved from the pouring box than in a trough tundish. But, trapezoidal tundishes has some disadvantage when compared to trough shapes because of the increased refractory costs, tundish skull weights, size of FMDs(flow modified device) and heat losses owing to the greater amount of surface area exposure.

Boat and V-shape tundish forms recirculation zone on both side of inlet because of the presence of the pouring box at center of two walls. Where as in case of T-shape tundish recirculation zone doesn't form on either of the two side because distance of the wall from inlet being too far . However, turbulence near the inlet remains reasonably high in all the three cases.



Billet and Bloom caster tundish configuration

Flotation of larger inclusions is generally adequate for all tundishes, although small inclusions (≤15 micrometer) do not tend to be floated effectively in any tundish configuration. Tundish depth is considered one of the key factor in facilitating inclusions removal and has been observed that longer tundishes with lower operating heights(depth) yield more efficient inclusions removal because shallower designs promote faster separation, as the relative distance to be covered by an inclusion during Stokes' Law flotation from the melt to the receptive slag interface is smaller. A shallower tundish also will provide better chemical transition compared to tundishes of equal volume but greater operating depth, owing to the mixing behavior of the streams. However, a shallower operating depth also carry disadvantages in terms of a reduced ability to dissipate turbulent ladle stream energy and a greater chances of top slag vortexing from the tundish into the mold during draining or ladle changeover where bath level can drop significantly.

The designer must therefore balance these issues before going ahead with construction of final tundish geometry.