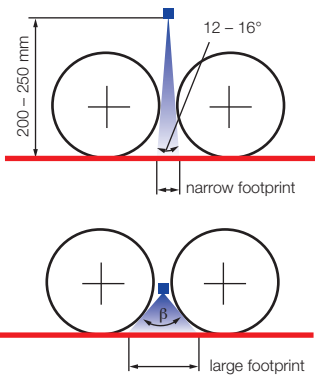


Mastercooler HARD HARD COOLING®

Hard Hard Cooling® (HHC)

The ability to cast low carbon steels at ever increasing casting speeds, while still be able to cast the more critical steel grades, requires a wider control and performance of the secondary cooling and as such, more flexibility in nozzle turnaround. Maintaining slab bulging at increased casting speeds requires both reduced roll pitches and increased secondary cooling intensities; the latter can lead to unacceptable temperature fluctuation on the slab surface with standard secondary cooling design. Mastercooler HHC nozzles cover a flow rate range from 1.8 to 49 l/min.

One technology which provides a solution to these problems is „Hard-Hard“ cooling which is the ability to apply large quantities of spray water to the slab surface reducing the slab surface to below 700 °C while maintaining acceptable surface temperature fluctuations. This practise requires a special nozzle design and arrangement in the top zone of a slab caster.

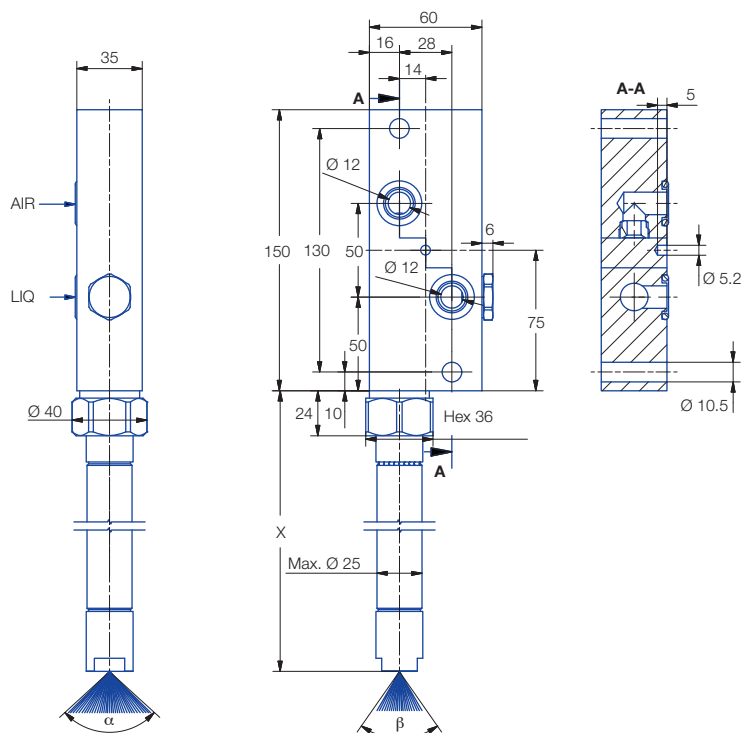


Spray footprint for conventional air-mist nozzle (top) and HHC nozzle (lower)



| Nozzle type | Max. water flow rate | Operating water pressure | Air flow rates | Operating air Pressure | Spray angle |
|-------------------------|----------------------|--------------------------|----------------|------------------------|-----------------------------|
| Mastercooler HHC | 49 l/min | 0.5 – 10 bar | 0.5 – 44 m³/h | 1 – 4 bar | 90-125° wide 20-75° deep |

Benchmark data only, individual nozzle data to be specified



Mastercooler Hard Hard Cooling® nozzle, SMART® mounting method and slim tip design



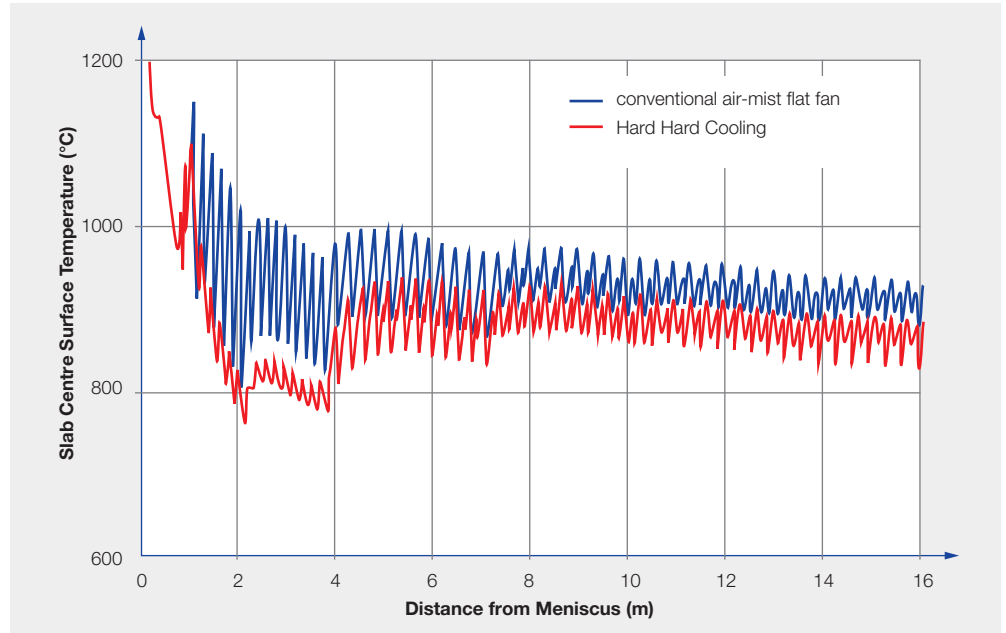
The minor spray angle of conventional nozzles, also called the spray thickness angle, ranges between 12° and 16° for typical major spray angles of 60° to 120° (wide axis). With spray heights of 160 mm to 300 mm in the upper cooling zones. The slab surface between roll contact and spray water remains uncooled and high temperature fluctuations within the roll gap can occur.

Slab defects attributable to secondary cooling can be minimised or avoided reducing these surface temperature fluctuations. „Hard-Hard“ cooling is a technology developed to address this issues as well as inter roll slab bulging.

„Hard-Hard“ cooling technology also requires that the strand surface temperature is reduced quickly to around 700 °C or less in the first cooling zone after the mould sprays, this temperature is then maintained throughout the complete solidification length of the strand.

The necessary temperature profile requires high cooling intensities through high water flows. When these water flows are applied through normal flat fan nozzles, large cyclic temperature fluctuations occur on the slab surface.

These cyclic fluctuations in the upper cooling zones of the caster can result in significant thermal stresses in the cast strand which could lead to the generation of both internal and surface defects.



Intense cooling profile conventional flat fan air-mist vs „Hard-Hard“ cooling nozzles

Reducing the surface temperature fluctuations to acceptable levels, while still extracting the necessary heat from the slab surface, requires that the spray thickness in the casting direction is maximised within the roll gap. This is achieved with a new Lechler design concept - “Hard-Hard” cooling nozzle.

The main difference with respect to surface temperature between the conventional flat fan nozzles and the new “Hard-Hard” concept is shown by the reduction of the surface temperature fluctuations in zone 1, the “Hard-Hard” cooling nozzles also require less spray water to achieve the required cooling due to their increased minor spray angle which produces a larger sprayed thickness on the slab surface.

With the low surface temperatures associated with „Hard-Hard“ cooling, the loss of cooling due to clogged nozzles will result large localised slab surface reheats. These reheats will produce large localised thermal stresses and possible defects. “Hard-Hard” cooling air-mist nozzles benefit from a non clogging nozzle tip featuring a single slot principle so giving users the benefits of both the highest operational safety and reduced maintenance.



HHC nozzle tip

Hard-Hard cooling nozzles are mounted utilising the proven Lechler Master-Cooler SMART method which has become an industry standard.

Hard Hard Cooling means improved slab quality and higher productivity due to:

- Lower strand temperatures in upper part of machine
- Minimized strand bulging and mould level instability
- Reduced temperature fluctuations on slab surface
- Increased quality and productivity
- Fitted Nozzle tip in roll gap
- Standard Mastercooler SMART mounting method