7 Sprayng Hot Surfaces for Making Steel and Other Metals

7.1 Continuous Casting

7.1.1 Introduction

The share of continuous casting in the world of steel production is steadily increasing. An essential reason for the rapid advance of continuous casting methods in steel-making is the capability of producing slabs, blooms or billets, as a “strand” directly from the melt. This universal method offers great advantages over former casting and rolling of single ingots; advantages are: fewer phases of operation, higher output of raw steel and high productivity. However, technology and quality demands on steel grades are steadily increasing. A constantly growing range of high alloy steels must be cast without cracks whilst giving optimized metallurgical properties.

For production of perfect steel grades cooling of the red-hot strand, especially in the secondary cooling area, is of vital importance. A good secondary cooling

Figure 7.1 Photo of the bend in a continuous casting machine

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depends on the following prerequisites:

- Uniform cooling of the strand surface
- High cooling efficiency due to high evaporation quotas of the cooling water
- Short dwell time of non-evaporated cooling water on the strand surface.

Figure 7.1 shows a photograph of the bend in a curved-mould multiple-strand continuous casting machine, which is the first zone in the process where cooling with water sprays is applied.

### 7.1.2 Process Description

The principle of heat removal from the steel in a continuous casting machine is shown in Figure 7.2 [1]. Primary cooling is achieved by water-cooling of the mould, into which the liquid steel is poured from the tundish. The steel starts to solidify, beginning on the surface. Secondary cooling, achieved by spray nozzles, is the next step in transferring heat from the steel [2]. This part of the cooling process is of vital importance and can be controlled by adequate design and operation of the spray system.

Tertiary cooling, after complete solidification of the steel, is the final part of the cooling process and is performed by radiation and convection of the heat into the ambient atmosphere.

An optimal cooling arrangement is one of the factors having an effect upon strand quality, especially when casting steels that are susceptible to cracking. A continuous casting machine works at variable speeds of strand withdrawal stipulated by the continuous casting process, i.e. speed-up, ladle change, pouring nozzle replacement, abnormal situations, etc. Selection of the cooling conditions and their precise achievement requires that the machine is furnished with a dynamic control system.

Secondary cooling has to be balanced between high efficiency of the heat removal process, i.e. high production speed of the machine, and the avoidance of material damage, which can occur in the form of internal cracks or surface cracks. Thus the heat transfer of the water spray has to be known and the arrangement and selection of the nozzles has to be done accurately in order to guarantee an even distribution of the heat transfer coefficient over the width of the slab.

Figure 7.3 shows the design principle of a continuous casting machine. The steel is molten in a teeming ladle, poured into a tundish and then fills a water-cooled mould, which represents the primary cooling zone.

In the secondary cooling zone the steel is supported by rolls and a water-spray system is incorporated in the curved cooling chamber. The steel solidifies during the cooling process and thereafter is guided and straightened by a system of rolls and finally withdrawn to the cutter. Spray nozzles have to be arranged to spray into the gaps between the rolls with precision under hostile environmental conditions and the mechanical design of cooling systems is a challenge for the