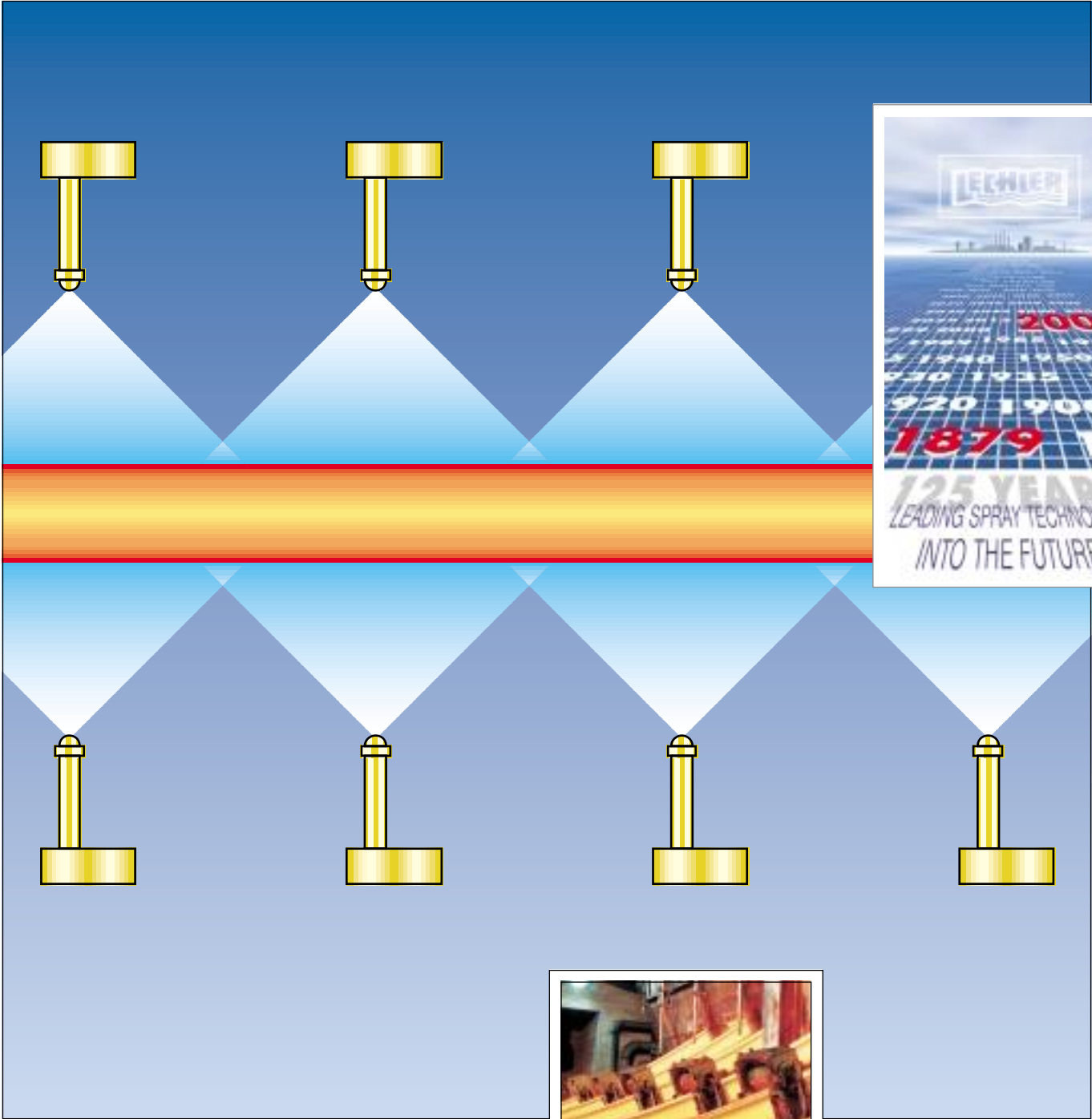




Spray Nozzles for Secondary Cooling in Continuous Casting Machines



Lechler - Advanced Spray Technology Based on 125 Years Experience

Today's steel producers have to operate in a tougher environment than ever before, caused by:

- Customer demand for improved quality
- Constant pressure on costs
- Fluctuating demand
- Tighter pollution controls

Pioneers in harnessing spray technology to steel production

Nozzles and spray systems are used in virtually every stage of steel production and their performance can have a major impact on product quality and manufacturing costs. For over 125 years, Lechler has pioneered developments in spray technology for all stages of primary metals production, designing, developing and manufacturing products of outstanding reliability and performance. All accompanied by expert advice based on a thorough knowledge of the industry, providing both conventional and innovative solutions. Today, Lechler offers the most comprehensive range of nozzles and spray systems for iron, steel and non-ferrous metals producers. From secondary cooling for continuous casting



to shape control in cold rolling mills and descaling, Lechler has a proven solution.

Lechler - synonymous with quality

The Lechler policy of continuous improvement and meticulous inspection is evidence of our commitment to whole life quality. From development, through manufacture to installation, Lechler products are subject to continuous quality management. State of the art test and inspection methods, often in excess of our ISO 9001 certification, guarantee the durability, reliability and longevity of Lechler spray nozzles and systems.

Automated production for consistent performance

Many of Lechler's automated manufacturing processes have been custom developed to guarantee not only optimum productivity, but also consistency of product parameters to exacting tolerances. Not only does every nozzle look like another of its type, but their spray characteristics will also be identical - guaran-

teed. This applies to every one of the 20,000 plus nozzle variants in our product portfolio, which differ by size, material and spray characteristics.

Serving steel producers worldwide

Lechler is a truly international company, offering sales and technical support to the metals industry worldwide. In addition to over 500 employees at our Metzingen headquarters in Germany, affiliated companies have plant and offices in the USA, the UK, India, China, France, Belgium, Sweden, Finland and Hungary. We also have a network of sales offices and representation covering many other countries.



Efficient Secondary Cooling - a Prerequisite for Optimising Steel Quality

Spray Cooling Methods

In Continuous Casting the secondary cooling system has an important influence on the quality of the cast products. Two different spray cooling methods are possible:

1. **Conventional cooling** via single fluid nozzles using only water.
2. **Airmist cooling** via 'twin fluid' nozzles using compressed air and water.

Whilst single fluid nozzle systems are less expensive to install and run, consuming less energy, twin fluid systems have three significant advantages in continuous casting, which outweigh initial and running costs:

- Wider water control range, typically from a ratio of 1:5 up to 1:25.
- Higher Heat Transfer Coefficient values at identical nozzle flow rates.
- Larger water and air bores, which virtually eliminate nozzle clogging.

For these reasons, airmist cooling is the favoured method for modern slab casting.

Heat transfer considerations

Careful evaluation of data obtained by measurements has confirmed that heat transfer depends on two major factors - the density of the sprayed water and its kinetic energy.

The degree to which one or the other factor dominates depends on the nozzle design and operating conditions. This is due to a condition called the Leidenfrost Phenomenon, in which a steam/vapour layer prevents the sprayed water making direct contact with the target surface.

However, when water droplets with a high kinetic energy break through this vapour layer, the heat transfer coefficient is significantly increased, with consequent higher cooling efficiency.

The configuration of nozzles is

dependant on slab size and spray height - a single spray nozzle, a pair of nozzles or a series of nozzles are installed between the support rollers covering the full width of the slab. The arrangement is designed to ensure a uniform liquid distribution across the slab width throughout all operating conditions.

Foot roller installations

For installations in the narrow gap between the mould and foot rollers, an array of single fluid flat jet nozzles (Lechler series 660, 664 or 665) is often used. These are specified due to their narrow spray pattern, but oval cone nozzles (Lechler series 400) can also be used.

Bending and straightening installations

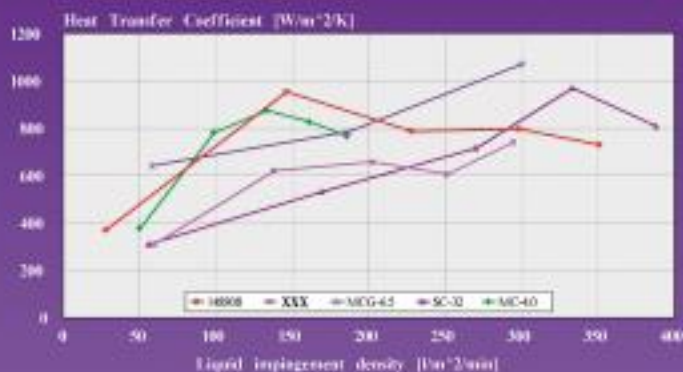
For these applications, standard single fluid flat jet nozzles and 148 series Block nozzles are generally installed with a large overlap, due to their parabolic liquid distribution. This aids uniform liquid distribution across the slab width throughout the turndown ratio range (minimum to maximum water flow/pressure). It also contributes to safety as, if a nozzle clogs, the two adjoining nozzles will cool its target area, preventing that section of the slab surface from receiving no cooling at all.

In zones further down the strand, a single flat jet nozzle can be installed in each roller gap. To cover the slab width, it is recommended that wide angle flat jet nozzles with 120° up to 140° spray angles, or even with rectangular spray patterns, are specified. Choice can be made from series 100 Twinorifice Block, Mastercooler or Slabcooler nozzle types.

More common in modern casting plants is a multi-nozzle arrangement of airmist nozzles in every gap, providing very uniform liquid distribution across the full width of the slab from minimum to maximum water flows. This arrangement also facilitates edge control by allowing the outer nozzles to be switched on and off.

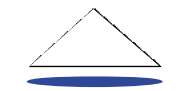
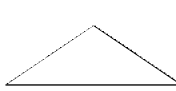
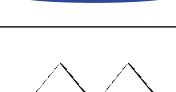

Mastercooler and Slabcooler nozzles are designed to provide such extremely uniform spray patterns.

Heat Transfer of Twin Fluid Nozzles
148-208 / XXX / MCG-4.5 / SC-32 / MC-4.0

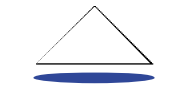

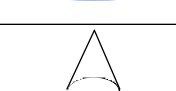
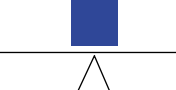
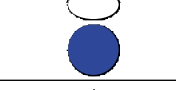


Choose the Right Nozzle for Your Application

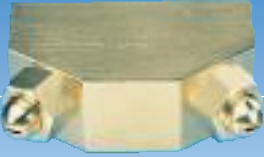







Twin Fluid Nozzles

Product / Spray pattern	Slab	Thin Slab	Bloom	Billet	Beam-Blank	Round
	X	X	X	X	X	X
	-	-	X	X	X	-
	X	-	-	-	-	-
	-	-	X	X	-	-

Single Fluid Nozzles





	X	X	X	X	X	X
	X	X	X	X	X	-
	-	X	X	X	-	-
	-	X	X	X	-	-
	X	-	X	X	-	-

Twin Fluid Nozzles

Example of nozzle type	Spray characteristics/ water distribution	Product no.	Spray angle	Nozzle size from – up to						Turn down ratio at 2 bar air (1 bar/7 bar water)	Material			Connection (acc. to size)		Applications	Advantages/ Features
				1 bar Water		2 bar Water		7 bar Water			Brass	303 SS	Brass, nickel plated	Water	Air		
				Water	Air	Water	Air	Water	Air								
	 Flat jet/ parabolic	100.XXX	150°	min.	1,5	28	5,5	23,5	16	13	1:10 1:20	X	X	3/8 NPT 3/8 BSPP Console	3/8 NPT 3/8 BSPP Console	Slab	<ul style="list-style-type: none"> ■ Finest droplet spectrum ■ Wide turn down ratio of flow rate ■ Large, free cross sections ■ Strong flow impuls ■ Quick and easy cleaning ■ Patented mixing insert ■ Self aligning tip
				max.	1,8	60	13,5	40	42	20							
	 Full cone/ circular	138.XXX	30° 60° 90°	min.	0,45	14	2,0	10	6,5	4	1:15	X	X	Console	Console	Billet, Bloom	
				max.	0,95	25,2	4,2	18	13,6	7,2							
	 Flat jet/ parabolic	148.XXX	30° 60° 90° 120° 140°	min.	0,5	19	1,6	18	4	16,5	1:35	X	X	1/4 NPT 1/4 BSPP Console	3/8 NPT 3/8 BSPP Console	Billet, Bloom, Slab	
				max.	0,95	70	8,5	50	28	28							
	 Flat jet/ even	124.XXX 128.XXX	90° 130° or to suit	min.	0,7	3,8	1,7	3,2	5	1,4	1:7	X	X	Console	Console	Slab, Thin slab	<ul style="list-style-type: none"> ■ High HTC values ■ Stable spray angle at all pressures and flows ■ Uniform water distribution ■ Nozzle length to suit
				max.	16	41	29	37	65	26							

Subject to technical modifications.









Twin Fluid Nozzles

Example of nozzle type	Spray characteristics/ water distribution	Product no.	Spray angle	\dot{V}_{Water} [l/min] and \dot{V}_{Air} [Nm ³ /hr] at 2 bar air constant						Turn down ratio at 2 bar air (1 bar/7 bar water)	Material			Connection (acc. to size)		Applications	Advantages/ Features	
				1 bar Water		2 bar Water		7 bar Water			Brass	303 SS	Brass, nickel plated	Water	Air			
				Water	Air	Water	Air	Water	Air									
																		min.
	 Flat jet/ even	184.XXX	80° 90° 100° 120° 130° or to suit	min.	2,25	9,8	3,6	9,5	8,6	6,8	1,5 (1:3*)	X	X	X (Tip)	3/8 BSPP 1/2 BSPP	3/8 BSPP 1/2 BSPP	Billet, Bloom, Slab, thin slab	<ul style="list-style-type: none"> ■ High HTC values ■ Stable spray angle at all pressures and flows ■ Uniform water distribution ■ Nozzle length to suit Other features possible: <ul style="list-style-type: none"> - 2 piece pipe - Bent pipe - Oval spray
			max.	8	60	18	55	50	23,5									
	 Flat jet/ even	186.XXX	80° 90° 100° 120° 130° or to suit	min.	2,25	9,8	3,6	9,5	8,6	6,8	1,5 (1:3*)	X	X	X (Tip)	Console	Console	Billet, Bloom, Slab, Thin slab	<ul style="list-style-type: none"> ■ High HTC values ■ Stable spray angle at all pressures and flows ■ Uniform water distribution ■ Nozzle length to suit Other features possible: <ul style="list-style-type: none"> - 2 piece pipe - Bent pipe - Oval spray
			max.	8	60	18	55	50	23,5									

* In case of variable air pressure









Subject to technical modifications.

Single Fluid Nozzles

Example of nozzle type	Spray characteristics/ water distribution	Product no.	Spray angle	V _{Water} [l/min] min/max			Turn down ratio (1 bar/7 bar water)	Material			Connection (acc. to size)	Applications	Advantages/ Features			
				at p [bar]				Brass	303 SS	Brass, nickel plated						
				1,0	2,0	7,0										
	 Flat jet/ parabolic	660.XXX	60° 90° 120°	min.	0,71	1,00	1,87	1:2,65	X	X	-	Dovetail Retaining nut 3/8 BSPP	Slab, Bloom: footroller area, first segments	<ul style="list-style-type: none"> ■ Compact, defined spray pattern ■ High energy spray jet 		
			max.	7,07	10,0	18,71										
	 Flat jet/ parabolic	652.XXX	60° 90° 120°	min.	0,71	1,00	1,87	1:2,65	X	X	-	Retaining nut 3/8 BSPP				
	 Flat jet/ rectangu- lar, even	664.XXX	60° 90° 120°	min.	4,45	6,3	11,79	1:2,65	X	-	-	Dovetail Retaining nut 3/4 BSPP			Slab, Bloom: single nozzle arrangement	
			max.	28,28	40,00	74,83										
	 Flat jet/ rectangu- lar, even	656.XXX	60° 90° 120°	min.	4,45	6,3	11,79	1:2,65	X	-	-	Retaining nut 3/4 BSPP				
			max.	28,28	40,00	74,83										

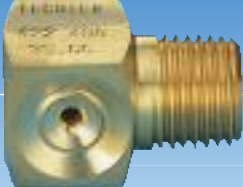





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Single Fluid Nozzles

Example of nozzle type	Spray characteristics/ water distribution	Product no.	Spray angle	V _{Water} [l/min] min/max			Turn down ratio (1 bar/7 bar water)	Material			Connection (acc. to size)	Applications	Advantages/ Features
				at p [bar]				Brass	303 SS	Brass, nickel plated			
				1,0	2,0	7,0							
	 Full cone/ circular, even	460.XXX	45° 60° 90° 120°	min. 0,76 1,0 1,65	max. 7,58 10,0 16,51	1:2,2 up to 1:2,5	X	X	-	1/8 BSPT 1/4 BSPT 3/8 BSPT	Billet, Bloom (Rounds): as well as Slabcaster for narrow side or footroller area	■ Stable spray angle	
	 Full cone/ circular, even	468.XXX SZU	45° 60° 90° 120°	min. 0,76 1,0 1,65	max. 7,58 10,0 16,51	1:2,2 up to 1:2,5	X	X	-	Retaining nut 3/8 BSPT	Billet, Bloom (Rounds): as well as Slabcaster for narrow side or footroller area	■ Stable spray angle	
	 Full cone/ square, even	463.XXX SZUQ	90°	min. 1,36 1,8 2,97	max. 7,58 10,0 16,51	1:2,2	X	-	-	Retaining nut 3/8 BSPT	Thin slab, Slab (footroller area)	■ Stable spray angle	
	 Full cone/ square, even	464.XXX	60° 75° 85° 115°	min. 0,95 1,25 2,06	max. 7,58 10,0 16,51	1:2,2	X	X	X	1/4 BSPT 3/8 BSPT 1/8 NPT 1/4 NPT	Thin slab, Slab (footroller area)	■ Stable spray angle	

Subject to technical modifications.

Single Fluid Nozzles

Example of nozzle type	Spray characteristics/ water distribution	Product no.	Spray angle	\dot{V}_{Water} [l/min] min/max			Turn down ratio (1 bar/7 bar water)	Material			Connection (acc. to size)	Applications	Advantages/ Features	
				at p [bar]				Brass	303 SS	Brass, nickel plated				
				1,0	2,0	7,0								
	 Full cone/ circular, even	422.XXX	60° 90° 120°	min.	0,71	1,0	1,87	1:2,6	X	-	X	1/4 BSPT 3/8 BSPT	Billet, Bloom (Rounds):	<ul style="list-style-type: none"> Large free cross sections, nonclogging sensitive
			max.	11,31	16,0	29,9								
	 Full cone/ oval, even	400.XXX	90°	min.	3,37	4,45	7,34	1:2,2	X	-	-	1/8 BSPT 1/4 BSPT 1/8 BSPT	Thin slab, Slab (e.g. footroller area)	<ul style="list-style-type: none"> Stable spray angle
				max.	5,1	6,85	11,31							
	 Full cone/ circular, even	436.XXX	45° 50° 65° 80° 90°	min.	1,5	2,1	3,95	1:2,6	X	-	-	1/4 BSPT inner 3/8 BSPT inner	Billet casters from CONCAST	<ul style="list-style-type: none"> Stable spray angle
				max.	9,85	14	26,1							

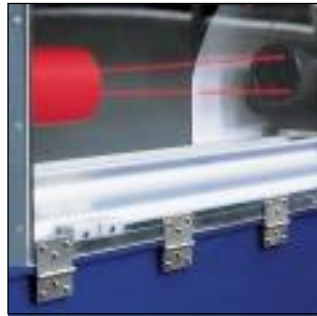
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Improved Performance Measurement Optimises Nozzle Design

The basis for optimising the design of nozzles is the ability to accurately and precisely measure and analyse performance. Lechler has developed its own techniques to produce reliable data on volume, droplet size, liquid distribution and heat transfer. Such data is then applied in the development, design and manufacture of nozzles to optimise their performance.

Every nozzle comes with complete documentation detailing its performance characteristics, typically including:

- Water/air flow diagram
- Water flow diagram
- Spray width diagram
- Liquid distribution diagram
- Heat Transfer Coefficient diagram (on special request)

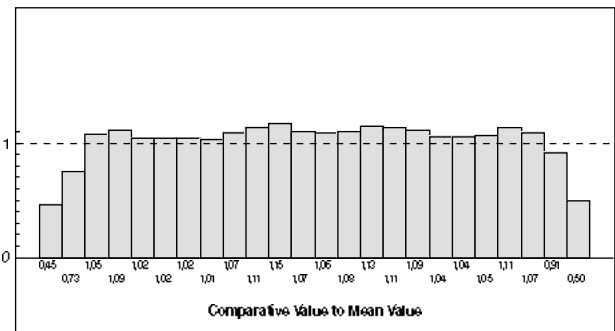


Liquid Distribution Single Nozzle (Example)

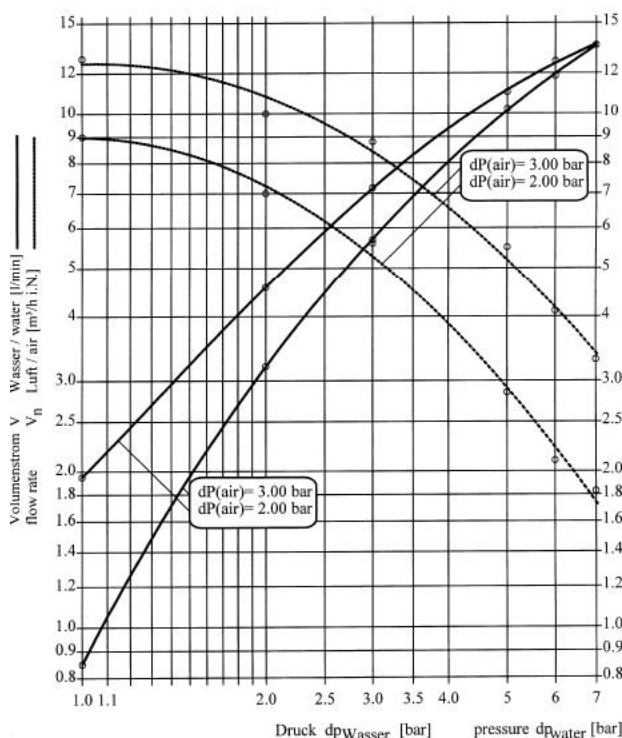
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Date: 20.03.95

Liquid Pressure: 2,00 bar	Nozzle Height: 80 mm
Liquid Flow rate: 4,60 l/min	Spray Width: 368 mm
Air Pressure: 2,00 bar	Mes. Point Dist: 16 m
Air Flow Rate: 730 m ³ /h i.N.	

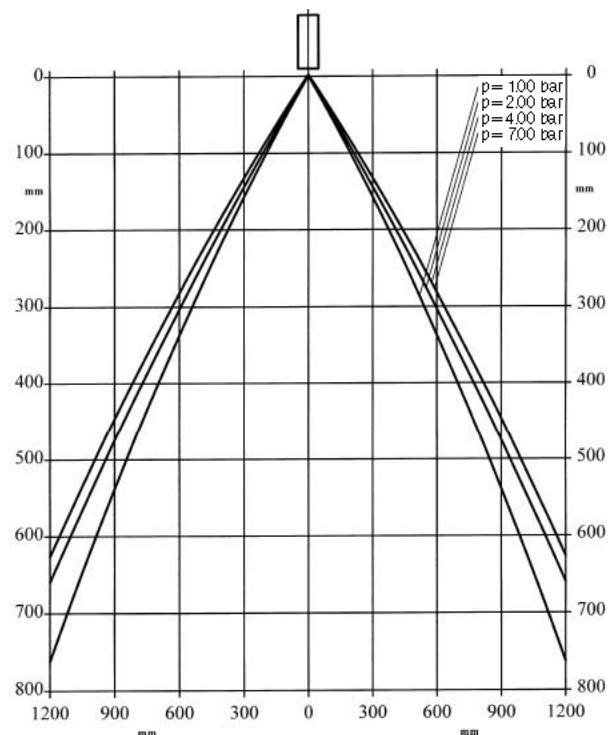
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Pressure-Flowrate-Diagram (Example)



Spray Width Diagram (Example)



Heat Transfer Coefficient Measurement

When designing cooling systems for Continuous Casting plants, engineers need to know the heat transfer coefficient to determine the specific nozzle arrangement, taking into account the surface conditions of the metal to be cooled.

The heat transfer can be affected by the Leidenfrost Phenomenon, which results when, due to the high surface temperatures, the water evaporates so intensely that a film of steam completely covers the surface, preventing the coolant reaching the hot metal.

The measurement of the heat transfer coefficient (HTC) has to cover the full range of surface temperatures that can occur in spray cooling processes in the metals industry.

Lechler measure the HTC by means of the 'Moving Nozzle Test', in which a steel plate is heated to 1200°C in inert gas and then cooled down to the temperature of the sprayed water.



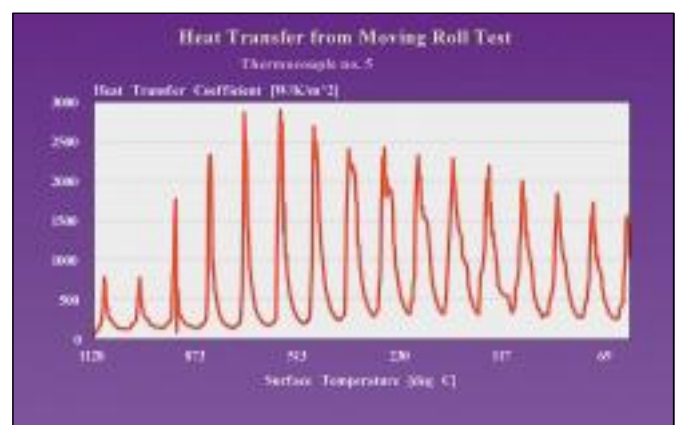
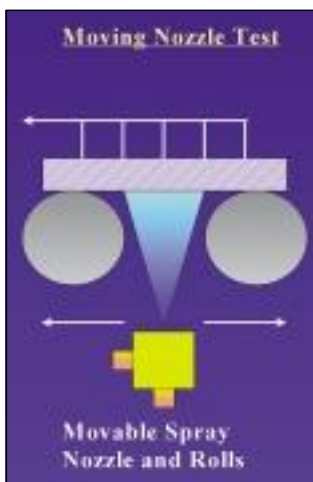
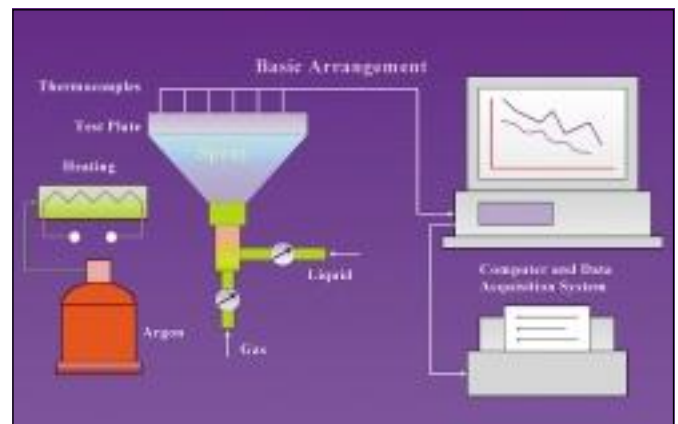
The HTC fluctuates as the nozzle moves over the thermocouple, with maximum HTC, signified by the peak values, occurring when water directly impinges on its position.

The objective is to simulate spray cooling of a moving steel strand. The spray is restricted by two cylindrical shapes representing the rolls used in continuous casting. Both the nozzle and 'cylinders' are installed in a moveable bed, enabling them to be moved parallel with, and longitudinally to, the plate.

When the desired temperature has been reached, the computerised control retracts the deflector and starts the quenching by switching on the nozzle motor. This moves the nozzle from left to right with the deflector open and reverses with the deflector closed.

The plate measures 600 x 320 mm with a thickness of 24 mm, and 24 thermocouples are uniformly positioned 3 mm below the quenched surface to measure temperatures. By continuously recording the data from these thermocouples a complete distribution of heat transfer rates can be computed.

A typical result is shown below, where the surface temperature from one thermocouple has been recorded.





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