



## Nozzles and Cooling Solutions for Continuous Casting of Steel

# Continuous Casting





Lechler are the world's leading spray technologists, with more than 125 years of experience in providing spray solutions to global leaders in manufacturing industries. Since the company was founded we have gained unsurpassed knowledge and experience which has enabled us to keep at the forefront of spray technology. Based on the knowledge we have gained we are fully aware of what is required by modern industry and how it can be achieved.



Headquarters, Germany



Lechler Ltd., United Kingdom

Lechler Inc., USA

Research and development plays a vital role in maintaining our global position. Teams of highly motivated engineers are constantly striving to develop new products and solutions that will assist you in maintaining the competitive edge in today's fast moving environment.

Our sales and technical specialists around the world have proven track records in building successful business partnerships wherever quality, performance and reliability are important. Allow Lechler engineering to assist you to drive your manufacturing process forward.



# Nozzles and Cooling Solutions for Continuous Casting of Steel

## Secondary cooling

The demand for improved product quality and increased productivity has focussed attention on the need for more efficient systems of spray cooling during continuous casting. Nozzle characteristics must be investigated and test procedures developed to measure cooling patterns and heat transfer. Lechler has developed new nozzles with higher heat transfer coefficients, better water distribution performances and larger free passages.

There are also important operational benefits such as:

- Increase of casting speed and production capacity
- Expansion of product mix to more profitable special steel grades
- Help to solve product quality problems including surface defects, corner cracking and core segregation
- Reduction of maintenance costs

## Nozzle parameters

A defect free slab, bloom, billet or beam blank and an economical operation are the objectives to be achieved by the spray nozzle cooling system. The nozzle manufacturer must have detailed knowledge of the behaviour of the nozzles under operation conditions and the machine segment design.

Of particular concern are:

- Nozzle type selection according to the product mix and machine design
- New nozzle designs
- Heat transfer coefficients measurements of the spray nozzles
- Air-water ratio
- Water turn-down ratio
- Water distribution
- New methods of nozzle mounting and new header pipe designs

## Nozzles for every caster

From simple billet casters for rebars to sophisticated machines for tire cord grades or for casters for beam blanks and round blooms, Lechler offers the optimal nozzle solutions both for water only

cooling or air mist systems. The same goes for thick or thin slab casters. Solutions for HARD-HARD® INTENSIVE COOLING and SOFT REDUCTION applications are available, too.



# Nozzles and Cooling Solutions for Continuous Casting of Steel

## Diagnosing capabilities

In recent years, Lechler has made major advances in spray cooling system analysis. As a result, Lechler have enlarged the scope of our offering to complete audits including solidification modelling of current secondary cooling systems to identify problems and “weak links” of the existing configuration. From that we can design a new system customized around the specific objectives and new requirements:

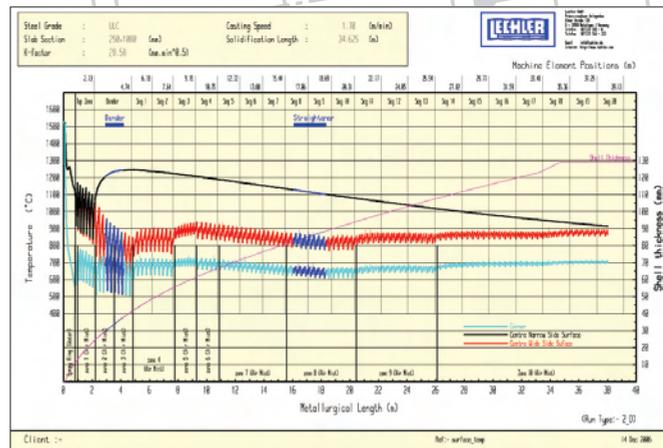
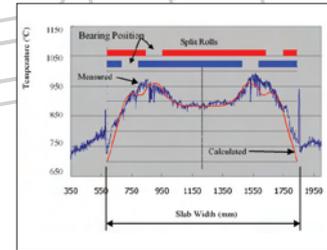
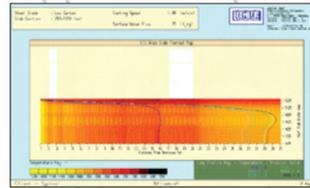
- Final product quality characteristics
- Steel grades and alloys

- Overall caster configuration
- Strand support layout
- Casting speeds
- Soft reduction parameters

All elements that are critical to the caster operation are covered:

- Solidification modelling, bench marking and analysis
- Nozzle selection and supply
- Nozzle header and piping design and fabrication
- Installation supervision

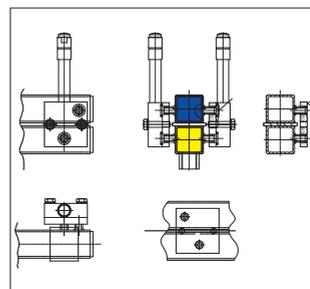
Lechler is the only spray nozzle manufacturer who offers such a wide range of capabilities.



## Nozzle header and segment pipe design

Strand surface defects can often be traced back to misaligned spray nozzles. Conventional, complex header pipes with many hoses are one source of such misalignments. With the introduction of the Lechler MasterCooler SMART® air mist nozzles the vertical segment piping with square air and water header pipes has become a design standard for slab caster segments. This nozzle

mounting system reduces the complexity of the segment piping, makes it very rigid and maintenance friendly, eliminates all hoses and small fittings and it secures correct nozzle positioning. Lechler has the ability to carry out the basic and detailed design for an optimized segment piping and nozzle headers. Fabrication, installation and commissioning can also be offered.



# Nozzles and Cooling Solutions for Continuous Casting of Steel



## Performance measurements

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.

## Water and impact distribution

It is the spray nozzle manufacturer's task to design nozzles providing the desired water distribution over the entire turn down ratio. In a slab caster the uniformity of the water distribution across the entire strand surface is essential for good quality slab. In billet- and bloom casters over spraying and hence overcooling of corners is to be avoided. The standard method to measure the water distribution especially if it comes to multi nozzle arrangements, is the patternator which measures the water density.

There are also other factors than the water density which can influence the cooling which are the air-water ratio, the turn down ratio and the pattern of the spray foot print of the air-mist nozzles.

The spray patterns can be measured more accurately with a new impact measurement device. This allows measuring the spray thickness and width simultaneously with an impact sensor which scans through the entire spray.

## Heat transfer coefficient measurement

The Heat Transfer Coefficient (HTC) of spray nozzles is decisive for the design for secondary cooling system. Lechler measures 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 objective is to simulate spray cooling of a moving steel strand.

For very larger nozzles with a higher cooling capacity required for HARD-HARD® INTENSIVE COOLING Lechler utilizes the liquid core HTC measurement method.

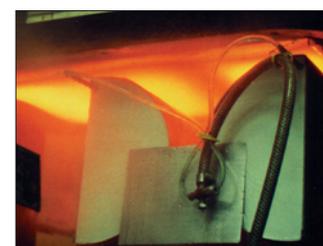
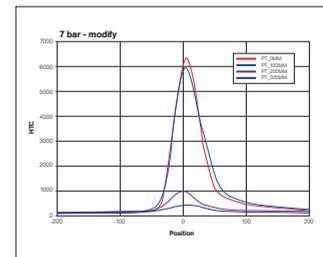
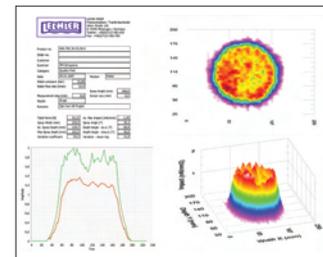
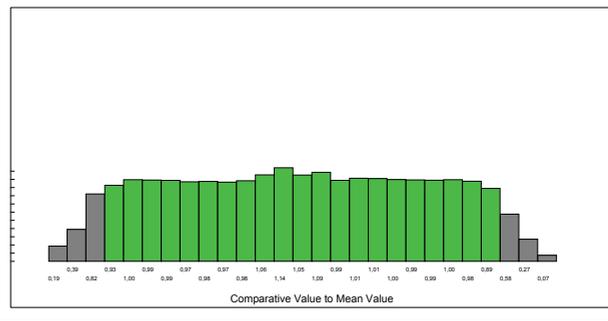
### LIQUID DISTRIBUTION

Pro.-No.: 1PM.004.35.03.00.0  
Date: 29.10.1999

### SEVERAL NOZZLES

Liquid Pressure:	6,00 bar	Nozzle Height:	254 mm	Variat. Coeff.:	5,23 %
Liq. Flow Rate:	15,60 l/min	Spray Width:	1300 mm	Max. Diff to Top:	14,20 %
Air Pressure:	2,00 bar	Mes. Point Dist.:	50 mm	Max. Diff to Bot.:	10,96 %
Air Flow Rate:	7,30 m <sup>3</sup> /h I.N.	Dist. betw. Nozz.:	570 mm	No. of Nozzles:	2

Remark:





Lechler GmbH  
 Precision Nozzles • Nozzle Systems  
 P.O. Box 13 23  
 72544 Metzingen / Germany  
 Phone: +49 (0) 71 23 962-0  
 Fax: +49 (0) 71 23 962-333  
 E-Mail: info@lechler.de  
 Internet: www.lechler.de

## Full Cone Nozzles with secured vane

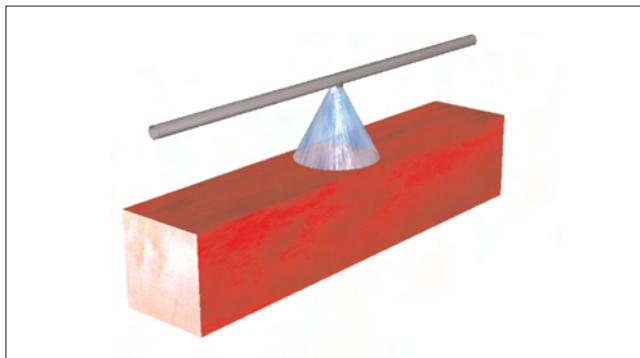
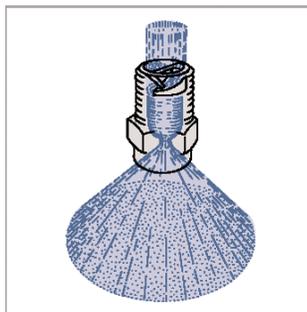
### The nozzle

Axial full cone nozzles with x-vanes are very common for secondary cooling in billet casters. The circular spray pattern available in standard spray angles from 45°, 60°, 90° and 120° allows to cover different formats and to cool the strand surface uniformly. The nozzles are either installed on spray rings or on "Banana-Headers" installed in parallel to the strand on all four sides.

### The problem

In Continuous Casting the secondary cooling system has an important role to play for the product quality and productivity of the machine. In billet casters axial full cone nozzles for conventional (single fluid) cooling with water only are very common.

When casting starts very low flows or no water is applied onto the strand surface. The same happens during a change of the tundish or when the machine is starving of liquid steel from the steel making department. During these periods, when no water is supplied through the nozzles the nozzle outer body is exposed to high temperatures from the strand but it is not cooled internally by cooling water.



When colder secondary cooling water is now sprayed, the cold cooling water cools the internal nozzle x-vane faster than the nozzle outer body. As a result the internal x-vane can get loose and can get lost through the supply pipe when the water is turned off again. An undefined solid jet will then be pro-

duced by such a nozzle. This can lead to very critical surface defects of the strand.

### The solution

A wide variety of the Lechler standard axial full cone nozzle programme is available in a special version with

the secured vane. The x-vane is secured by a stainless steel ring which does not allow the x-vane to move backwards out of the nozzle. In fact the ring keeps the x-vane in place even in case of large temperature differences between the nozzle body and cooling water.

### The application

The axial full cone nozzles with secured vane have been designed for all billet and bloom casters with single fluid (water only) secondary cooling. They are also ideal for the cooling of slab casters for the cooling of the narrow face below the mould.

### The benefits

With the x-vane being secured the risk of malfunction of the nozzle and subsequent serious surface defects are practically eliminated. Hence, the operation safety is significantly increased.

### The availability

The Lechler axial full cone nozzle programme with secured x-vane is available with 3/8" (R3/8" EN 10226) and 1/2" (R1/2" EN 10226) male connections (see table). Standard material is brass, stainless steel 1.4571 (ss316) is available on special request.

LEADING SPRAY TECHNOLOGISTS



NOZZLES



LANCES



HEADERS



CONTROLS



SYSTEMS

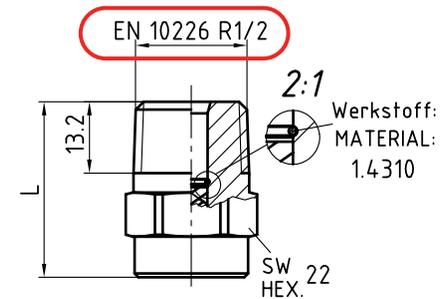
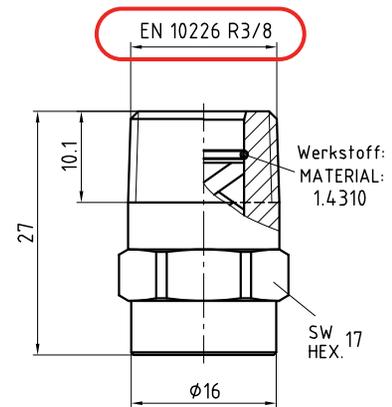


Lechler GmbH  
 Precision Nozzles • Nozzle Systems  
 P.O. Box 13 23  
 72544 Metzingen / Germany  
 Phone: +49 (0) 71 23 962-0  
 Fax: +49 (0) 71 23 962-333  
 E-Mail: info@lechler.de  
 Internet: www.lechler.de

## Full Cone Nozzles with secured vane

Spray Angle	Type in brass	R 3/8 EN 10226	R 1/2 EN 10226	B Ø [mm]	E Ø [mm]	flow rate V [l/min]							
						pressure p [bar]							
						0,5	1,0	2,0	3,0	5,0	7,0	10,0	
45°	460.443.30.	12	71	1,20	1,15	0,72	0,95	1,25	1,47	1,80	2,06	2,38	
	460.483.30.	12	71	1,35	1,20	0,92	1,21	1,60	1,88	2,31	2,64	3,05	
	460.523.30.	12	71	1,50	1,35	1,15	1,52	2,00	2,35	2,89	3,30	3,81	
	460.563.30.	12	71	1,70	1,55	1,44	1,89	2,50	2,94	3,61	4,13	4,76	
	460.603.30.	12	71	1,90	1,80	1,81	2,39	3,15	3,70	4,54	5,20	6,00	
	460.643.30.	12	71	2,15	2,00	2,30	3,03	4,00	4,70	5,77	6,60	7,61	
	460.683.30.	12	71	2,40	2,00	2,87	3,79	5,00	5,88	7,21	8,25	9,52	
	460.703.30.	12	71	2,55	2,20	3,22	4,24	5,60	6,59	8,08	9,24	10,66	
	460.723.30.	12	71	2,70	2,35	3,62	4,77	6,30	7,41	9,09	10,40	11,99	
	460.743.30.		71	2,80	2,60	4,08	5,38	7,10	8,35	10,24	11,72	13,52	
	460.763.30.		71	3,00	3,00	4,59	6,44	8,00	9,41	11,54	13,20	15,22	
	460.783.30.		71	3,20	3,20	5,17	6,82	9,00	10,58	12,98	14,85	17,12	
	460.803.30.		71	3,40	3,30	5,74	7,58	10,00	11,76	14,43	16,51	19,04	
	460.843.30.		71	3,80	3,70	7,18	9,47	12,50	14,70	18,03	20,63	23,80	
460.883.30.		71	4,30	4,30	9,19	12,13	16,00	18,82	23,08	26,41	30,46		
60°	460.444.30.	12	71	1,30	1,05	0,72	0,95	1,25	1,47	1,80	2,06	2,38	
	460.484.30.	12	71	1,45	1,15	0,92	1,21	1,60	1,88	2,31	2,64	3,05	
	460.524.30.	12	71	1,60	1,20	1,15	1,52	2,00	2,35	2,89	3,30	3,81	
	460.564.30.	12	71	1,80	1,30	1,44	1,89	2,50	2,94	3,61	4,13	4,76	
	460.604.30.	12	71	2,05	1,40	1,81	2,39	3,15	3,70	4,54	5,20	6,00	
	460.644.30.	12	71	2,40	1,90	2,30	3,03	4,00	4,70	5,77	6,60	7,61	
	460.684.30.	12	71	2,60	2,00	2,87	3,79	5,00	5,88	7,21	8,25	9,52	
	460.704.30.	12	71	2,70	2,00	3,22	4,24	5,60	6,59	8,08	9,24	10,66	
	460.724.30.	12	71	2,90	2,00	3,62	4,77	6,30	7,41	9,09	10,40	11,99	
	460.744.30.	12	71	3,10	2,40	4,08	5,38	7,10	8,35	10,24	11,72	13,52	
	460.764.30.	12	71	3,25	2,85	4,59	6,44	8,00	9,41	11,54	13,20	15,22	
	460.784.30.	12	71	3,40	2,95	5,17	6,82	9,00	10,58	12,98	14,85	17,12	
	460.804.30.	12	71	3,60	2,95	5,74	7,58	10,00	11,76	14,43	16,51	19,04	
	460.844.30.		71	4,00	3,30	7,18	9,47	12,50	14,70	18,03	20,63	22,80	
460.884.30.		71	4,50	3,70	9,19	12,13	16,00	18,82	23,08	26,41	30,46		
90°	460.446.30.	12		1,30	1,00	0,72	0,95	1,25	1,47	1,80	2,06	2,38	
	460.486.30.	12		1,45	1,20	0,92	1,21	1,60	1,88	2,31	2,64	3,05	
	460.526.30.	12		1,65	1,30	1,15	1,52	2,00	2,35	2,89	3,30	3,81	
	460.566.30.	12		1,85	1,30	1,44	1,89	2,50	2,94	3,61	4,13	4,76	
	460.606.30.	12		2,05	1,45	1,81	2,39	3,15	3,70	4,54	5,20	6,00	
	460.646.30.	12		2,30	1,80	2,30	3,03	4,00	4,70	5,77	6,60	7,61	
	460.686.30.	12		2,60	1,80	2,87	3,79	5,00	5,88	7,21	8,25	9,52	
	460.706.30.	12		3,00	1,80	3,22	4,24	5,60	6,59	8,08	9,24	10,66	
	460.726.30.	12		2,95	2,00	3,62	4,77	6,30	7,41	9,09	10,40	11,99	
	460.746.30.	12		3,30	1,90	4,08	5,38	7,10	8,35	10,24	11,72	13,52	
	460.766.30.	12		3,30	2,40	4,59	6,06	8,00	9,41	11,54	13,20	15,22	
	460.786.30.	12		3,70	2,30	5,17	6,82	9,00	10,58	12,98	14,85	17,12	
	460.806.30.	12		3,70	2,70	5,74	7,58	10,00	11,76	14,43	16,51	19,04	
	460.846.30.	12		4,05	3,20	7,18	9,47	12,50	14,70	18,03	20,63	23,80	
460.856.30.	12		4,15	3,20	7,58	10,00	13,20	15,52	19,04	21,79	25,13		
460.866.30.	12		4,30	2,30	8,05	10,61	14,00	16,47	20,21	23,12	26,67		
460.886.30.	12		4,70	3,10	9,19	12,13	16,00	18,82	23,08	26,41	30,46		
120°	460.448.30.	12		1,30	0,90	1,72	0,95	1,25	1,47	1,80	2,06	2,38	
	460.488.30.	12		1,50	1,00	0,92	1,21	1,60	1,88	2,31	2,64	3,05	
	460.528.30.	12		1,65	1,20	1,15	1,52	2,00	2,35	2,89	3,30	3,81	
	460.568.30.	12		1,90	1,35	1,44	1,89	2,50	2,94	3,61	4,13	4,76	
	460.608.30.	12		2,10	1,40	1,81	2,39	3,15	3,70	4,54	5,20	6,00	
	460.648.30.	12		2,45	1,60	2,30	3,03	4,00	4,37	5,77	6,60	7,61	
	460.688.30.	12		2,75	1,80	2,87	3,79	5,00	5,88	7,21	8,25	9,52	
	460.708.30.	12		3,00	1,80	3,22	4,24	5,60	6,59	8,08	9,24	10,66	
	460.728.30.	12		3,10	1,90	3,62	4,77	6,30	7,41	9,09	10,40	11,99	
	460.748.30.	12		3,30	1,90	4,08	5,38	7,10	8,35	10,24	11,72	13,52	
	460.768.30.	12		3,50	1,90	4,59	6,44	8,00	9,41	11,54	13,20	15,22	
	460.788.30.	12		3,70	2,30	5,17	6,82	9,00	10,58	12,98	14,85	17,12	
	460.808.30.	12		3,80	2,40	5,74	7,58	10,00	11,76	14,43	16,51	19,04	
	460.848.30.	12		4,20	2,70	7,18	9,47	12,50	14,70	18,03	20,63	23,80	
460.868.30.	12		4,40	2,70	8,04	10,61	14,00	16,47	20,20	23,11	26,65		
460.888.30.	12		4,36	3,10	9,19	12,13	16,00	18,82	23,08	26,41	30,46		

### Technical Data:



### Conversion formulars for axial full cone nozzles:

$$\dot{V}_2 = \left(\frac{p_2}{p_1}\right)^{0,4} \cdot \dot{V}_1 \text{ [l/min]}$$

$$p_2 = \left(\frac{\dot{V}_2}{\dot{V}_1}\right)^{2,5} \cdot p_1 \text{ [bar]}$$

B Ø = bore diameter; E Ø = narrowest free cross section

Example for ordering: Type + Material no. + Code = Ordering no.  
 460.443 + 30 + 71 = 460.443.30.71

### LEADING SPRAY TECHNOLOGISTS



NOZZLES



LANCES



HEADERS



CONTROLS



SYSTEMS



Lechler GmbH  
 Precision Nozzles • Nozzle Systems  
 P.O. Box 13 23  
 72544 Metzingen / Germany  
 Phone: +49 (0) 71 23 962-0  
 Fax: +49 (0) 71 23 962-333  
 E-Mail: info@lechler.de  
 Internet: www.lechler.de

## Full Cone Nozzles 486 series 3/8" female thread

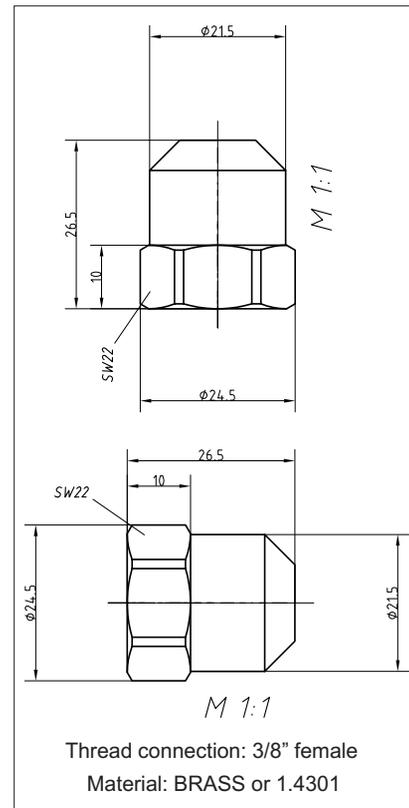


Full cone nozzles with R 3/8" female thread. Circular uniform full cone spray pattern. Very common in secondary cooling systems of billet and bloom casters designed and built by Concast.

Standard material brass, stainless steel as well as other spray angles and flow rates available on request

spray angle	Type	Mat.-No.		Thread code	Code	flow rate V [l/min]
		30	1C			pressure p [bar]
45°	486.443	●	●	AF	1545 L	1,50
	486.493	●	●	AF	2045 L	2,00
	486.563	●	●	AF	3045 L	3,00
	486.593	●	●	AF	3545 L	3,50
	486.613	●	●	AF	4045 L	4,00
	486.653	●	●	AF	5045 L	5,00
	486.683	●	●	AF	6045 L	6,00
	486.713	●	●	AF	7045 L	7,00
	486.733	●	●	AF	8045 L	8,00

Example for ordering Type + Material no. + Thread Code = Ordering no.  
 486.444 + 1C + AF = 486.444.1C.AF



LEADING SPRAY TECHNOLOGISTS



NOZZLES



LANCES



HEADERS



CONTROLS



SYSTEMS



Lechler GmbH  
 Precision Nozzles • Nozzle Systems  
 P.O. Box 13 23  
 72544 Metzingen / Germany  
 Phone: +49 (0) 71 23 962-0  
 Fax: +49 (0) 71 23 962-333  
 E-Mail: info@lechler.de  
 Internet: www.lechler.de

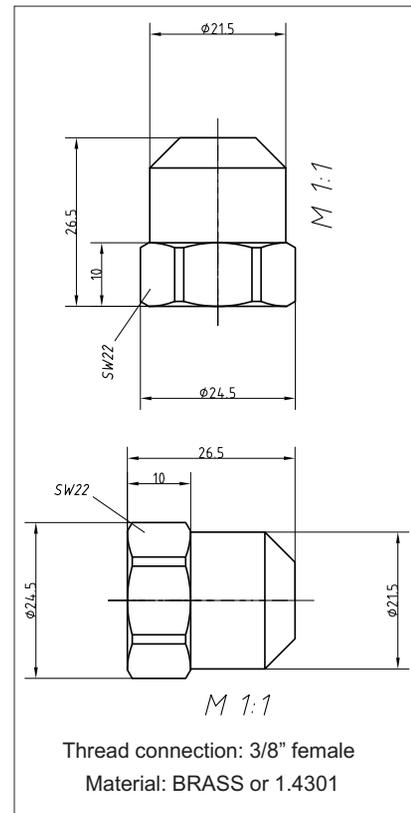
## Full Cone Nozzles 486 series 3/8" female thread

spray angle	Type	Mat.-No.		Thread code	Code	flow rate V [l/min]
		30	1C			pressure p [bar]
65°	486.444	●	●	AF	1565 L	1,50
	486.494	●	●	AF	2065 L	2,00
	486.534	●	●	AF	2565 L	2,50
	486.564	●	●	AF	3065 L	3,00
	486.594	●	●	AF	3565 L	3,50
	486.614	●	●	AF	4065 L	4,00
	486.634	●	●	AF	4565 L	4,50
	486.654	●	●	AF	5065 L	5,00
	486.674	●	●	AF	5565 L	5,50
	486.684	●	●	AF	6065 L	6,00
	486.704	●	●	AF	6565 L	6,50
	486.714	●	●	AF	7065 L	7,00
	486.724	●	●	AF	7565 L	7,50
	486.734	●	●	AF	8065 L	8,00
	486.744	●	●	AF	8565 L	8,50
	486.754	●	●	AF	9065 L	9,00
	486.764	●	●	AF	9565 L	9,50
	486.774	●	●	AF	10065 L	10,00
486.814	●	●	AF	12065 L	12,00	
486.834	●	●	AF	14065 L	14,00	
486.854	●	●	AF	15065 L	15,00	
486.864	●	●	AF	16565 L	16,50	

90°	486.446	●	●	AF	1590 L	1,50
	486.496	●	●	AF	2090 L	2,00
	486.536	●	●	AF	2590 L	2,50
	486.566	●	●	AF	3090 L	3,00
	486.596	●	●	AF	3590 L	3,50
	486.616	●	●	AF	4090 L	4,00
	486.636	●	●	AF	4590 L	4,50
	486.656	●	●	AF	5090 L	5,00
	486.676	●	●	AF	5590 L	5,50
	486.686	●	●	AF	6090 L	6,00
	486.706	●	●	AF	6590 L	6,50
	486.716	●	●	AF	7090 L	7,00
	486.726	●	●	AF	7590 L	7,50
	486.736	●	●	AF	8090 L	8,00
	486.746	●	●	AF	8590 L	8,50
	486.756	●	●	AF	9090 L	9,00
	486.766	●	●	AF	9590 L	9,50
	486.776	●	●	AF	10090 L	10,00
486.816	●	●	AF	12090 L	12,00	

100°	486.597	●	●	AF	36100 L	3,60
------	---------	---	---	----	---------	------

Example for ordering Type + Material no. + Thread Code = Ordering no.  
 486.444 + 1C + AF = 486.444.1C.AF



LEADING SPRAY TECHNOLOGISTS



NOZZLES



LANCES



HEADERS



CONTROLS



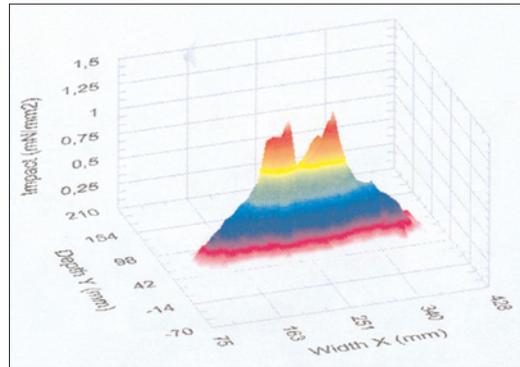
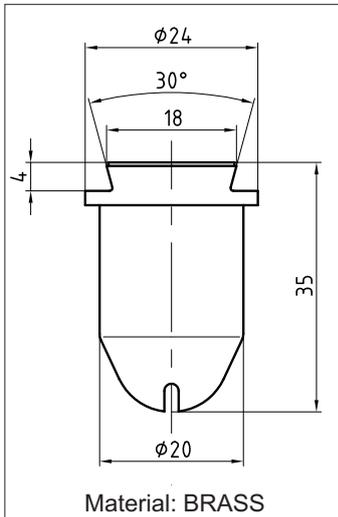
SYSTEMS



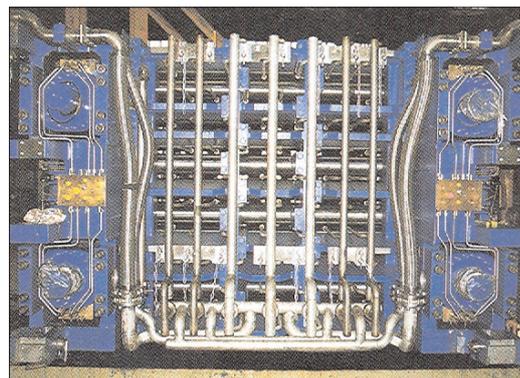
Lechler GmbH  
 Precision Nozzles • Nozzle Systems  
 P.O. Box 13 23  
 72544 Metzingen / Germany  
 Phone: +49 (0) 71 23 962-0  
 Fax: +49 (0) 71 23 962-333  
 E-Mail: info@lechler.de  
 Internet: www.lechler.de

## Flat Jet Nozzles with increased spray depth 600.366 series, **optimized high impact version**

Used in SMS Demag CSP<sup>®</sup> lines



Typical impact measurement of high impact version.



Position-controlled segments for LCR operation of a CSP plant, pre-assembled in the work shop.

Lechler-No.	Spray Width Angle [°]	Spray Depth Angle [°]	Flow Rate @ 5 bar [l/min]
High Impact Version			
600.366.30.40.00.0	105	20	7,0
600.366.30.41.00.0	105	20	10,4
600.366.30.42.00.0	105	20	13,5
600.366.30.43.00.0	105	20	17,3
600.366.30.44.00.0	105	20	9,5
600.366.30.45.00.0	105	20	21,5
600.366.30.46.00.0	105	20	2,8
600.366.30.47.00.0	105	20	5,9
600.366.30.48.00.0	105	20	9,1
600.366.30.49.00.0	105	20	3,6
600.366.30.50.00.0	70	20	5,7
600.366.30.51.00.0	70	20	7,0
600.366.30.52.00.0	70	20	10,4
600.366.30.53.00.0	70	20	2,8
600.366.30.54.00.0	70	20	3,6
600.366.30.55.00.0	70	20	4,3

LEADING SPRAY TECHNOLOGISTS

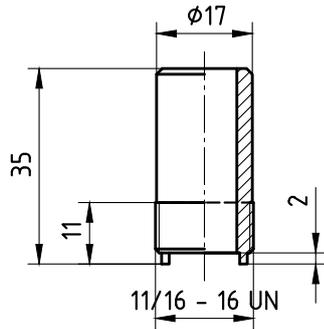




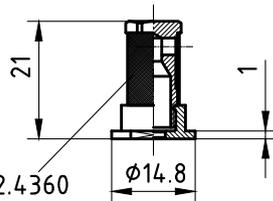
Lechler GmbH  
 Precision Nozzles • Nozzle Systems  
 P.O. Box 13 23  
 72544 Metzingen / Germany  
 Phone: +49 (0) 71 23 962-0  
 Fax: +49 (0) 71 23 962-333  
 E-Mail: info@lechler.de  
 Internet: www.lechler.de

## Flat Jet Nozzles & Accessories for thin slab casters

Used in SMS Demag CSP lines

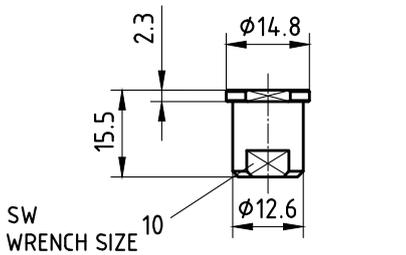


Schweißnippel Erz.-Nr.  
 WELDING NIPPLE NO.  
 600.353.17.00.01.0  
 MATERIAL: STAINLESS STEEL



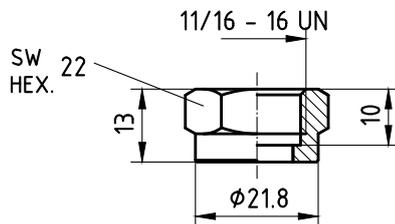
Werkstoff: 2.4360  
 MATERIAL:

Siebfilter Erz.-Nr.  
 STRAINER NO.  
 600.353.16.00.02.0  
 MATERIAL: STAINLESS STEEL



SW  
 WRENCH SIZE

Flachstrahldüse Erz.-Nr. FLAT JET NOZZLE NO.	Volumenstrom Wasser $\dot{V}_w$ bei 3 bar FLOW RATE WATER $\dot{V}_w$ AT 3 BAR	Strahlwinkel SPRAY ANGLE
600.353.30.00.00.0	1,6 l/min	65°
600.353.30.01.00.0	19,6 l/min	45°
600.353.30.02.00.0	15,3 l/min	45°
600.353.30.03.00.1	11,8 l/min	65°
600.353.30.04.00.0	15,8 l/min	25°
600.353.30.05.00.0	11,8 l/min	110°
600.353.30.06.00.0	11,8 l/min	80°
600.353.30.07.00.0	11,8 l/min	95°
600.353.30.08.00.0	19,6 l/min	95°
600.353.30.09.00.0	3,95 l/min	110°
600.353.30.10.00.0	11,8 l/min	25°
600.353.30.11.00.0	12,25 l/min	45°
600.353.30.12.00.0	9,8 l/min	45°
600.353.30.13.00.0	15,8 l/min	95°
600.353.30.14.00.0	3,86 l/min	90°



SW  
 HEX.

Überwurfmutter Erz.-Nr.  
 LOCK NUT NO.  
 065.203.30.01.00.0  
 MATERIAL: BRASS

Other nozzle sizes of the same type on request

LEADING SPRAY TECHNOLOGISTS



NOZZLES



LANCES



HEADERS



CONTROLS



SYSTEMS

**Patented**



Lechler GmbH  
 Precision Nozzles • Nozzle Systems  
 P.O. Box 13 23  
 72544 Metzingen / Germany  
 Phone: +49 (0) 71 23 962-0  
 Fax: +49 (0) 71 23 962-333  
 E-Mail: info@lechler.de  
 Internet: www.lechler.de

## BilletCooler - Full Cone Standard Version

### The problem

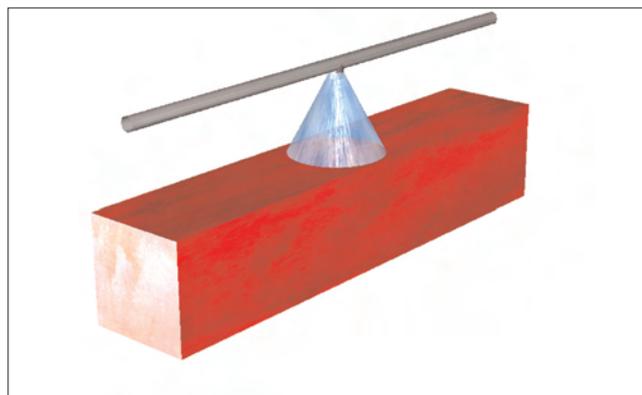
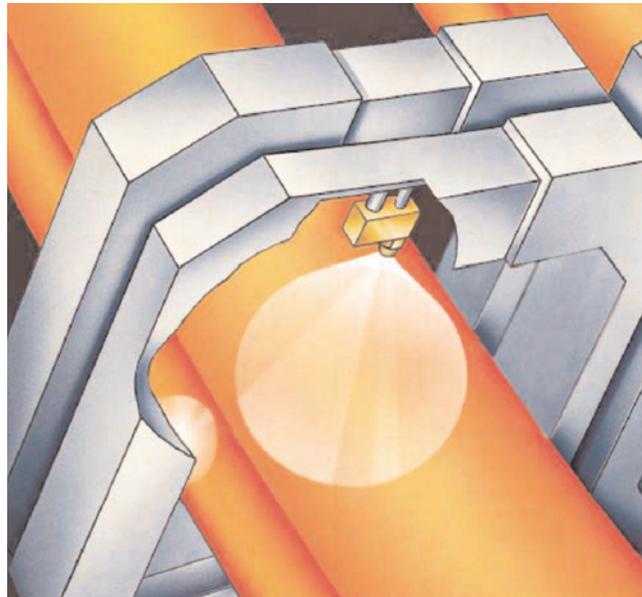
When air mist cooling becomes necessary for a billet or bloom caster flat jet nozzles may not always be the best choice. This is especially true where the formation of Halfway Cracks is experienced.

This type of cracks have shown to be caused by reheating of the surface of the strand after it has passed the sharp heat extraction zone beneath a spray jet. During this reheating process the surface expands and imposes a tensile strain on the interior, hotter and hence weaker regions of the solid shell which then can crack. The use of flat jet nozzles intensifies this effect. Full cone nozzles provide a homogenous cooling over an extended surface area.

These two spray patterns are the standard for single fluid water secondary cooling systems, however there has unfortunately not been an adequate version using air mist. Common full cone air mist nozzles show quite unstable spray performances, very high air consumptions and a tendency to clog very easily.

### The solution

BilletCooler full or oval cone air mist nozzles. With this new nozzle generation it is now possible to utilise air mist cooling also in billet and bloom casters as effectively as in slab casters.



The compact block design allows mounting either on horizontal spray rings but also on vertical nozzle headers. A turn down ratio as wide as 1 : 10 is standard at water pressures between 0,5 (1,0) and 7 bar at 2 bar air constant.

Nominal standard spray angles for circular full cone nozzles are 45°, 60° and 90°.

Free passages approximately three times larger than before makes the BilletCooler a real non clogging nozzle.

### The application

- Billet and bloom casters for higher steel grades such as stainless steels, special spring steel, tire cord steels etc. require more sophisticated cooling systems with higher turn down ratios and often smaller flow rates than hydraulic water nozzles can offer.
- Narrow face cooling in slab casters in the foot roll / top zone segment.
- Wide face cooling in slab casters with support grids in the top zone below the mould.

### The benefits

- High turn-down ratio (min./max. flow rate) 1:10 (max. 1:14) for high flexibility and extended product (steel grade) mix. reduces the number of different nozzle types in the machine.
- Compressed air consumption reduced by appr. 40% for low investment & operation costs
- High Heat Transfer Coefficient (HTC) for high casting speeds
- Compact design ideal for spray rings and vertical headers.
- Plate connection for easy and maintenance friendly mounting.
- Large free passages prevent clogging for high operation safety with improved plant availability.
- Successfully installed in more than 30 casters worldwide.
- Reduced maintenance costs.

LEADING SPRAY TECHNOLOGISTS



NOZZLES



LANCES



HEADERS



CONTROLS



SYSTEMS

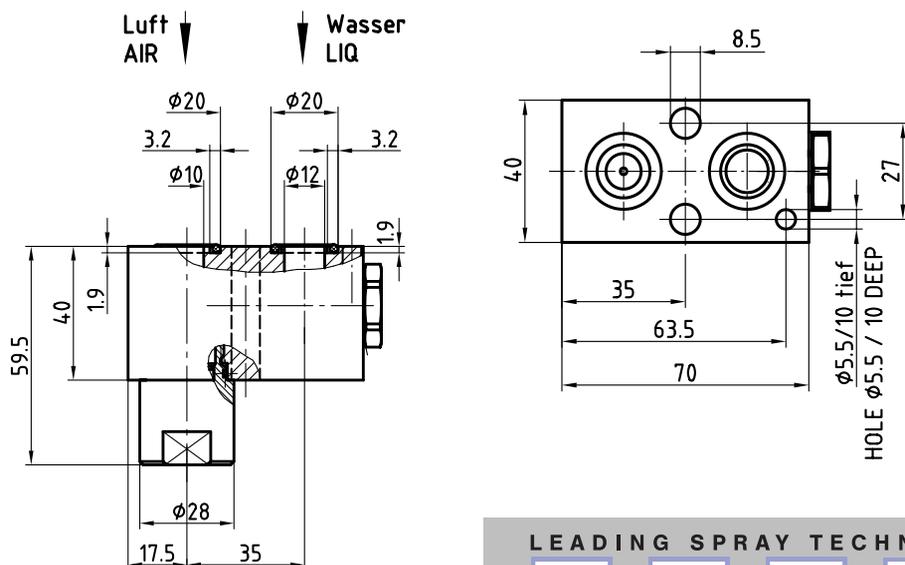
**Patented**



Lechler GmbH  
 Precision Nozzles • Nozzle Systems  
 P.O. Box 13 23  
 72544 Metzingen / Germany  
 Phone: +49 (0) 71 23 962-0  
 Fax: +49 (0) 71 23 962-333  
 E-Mail: info@lechler.de  
 Internet: www.lechler.de

## BilletCooler - Full Cone Standard Version

BilletCooler (Full Cone)					
		Min. standard water flow at 0,5 bar water pressure (if not other mentioned)	Max. standard water flow at 7 bar water pressure (if not other mentioned)	Max. standard air flow at 0,5 bar water pressure (if not other mentioned)	Nozzle Code
All values at 2 bar constant air pressure					
Size	Spray angle	l / min	l / min	Nm <sup>3</sup> / hr	
0,6	45°	0,5 (@1,5 bar)	2,8 (@6,5 bar)	3,8 (@1,5 bar)	1PM.021.30.68
0,6	60°	0,5 (@1,5 bar)	2,8 (@6,5 bar)	3,8 (@1,5 bar)	1PM.021.30.69
0,6	90°	0,5 (@1,5 bar)	2,8 (@6,5 bar)	3,8 (@1,5 bar)	1PM.021.30.70
0,9	45°	0,9 (@1,5 bar)	3,4 (@6,5 bar)	4 (@1,5 bar)	1PM.021.30.71
0,9	60°	0,9 (@1,5 bar)	3,4 (@6,5 bar)	4 (@1,5 bar)	1PM.021.30.63
0,9	90°	0,9 (@1,5 bar)	3,4 (@6,5 bar)	4 (@1,5 bar)	1PM.021.30.67
1	45°	0,40	4,0	4,0	1PM.021.30.72
1	60°	0,40	4,0	4,0	1PM.021.30.21
1	90°	0,40	4,0	4,0	1PM.021.30.41
1,25	45°	0,50	5,0	4,6	1PM.021.30.73
1,25	60°	0,50	5,0	4,6	1PM.021.30.20
1,25	90°	0,50	5,0	4,6	1PM.021.30.25
1,6	45°	0,60	6,0	6,0	1PM.021.30.74
1,6	60°	0,60	6,0	6,0	1PM.021.30.75
1,6	90°	0,60	6,0	6,0	1PM.021.30.76
1,8	45°	0,60	6,9	8,5	1PM.021.30.77
1,8	60°	0,60	6,9	8,5	1PM.021.30.78
1,8	90°	0,60	6,9	8,5	1PM.021.30.79
2,0	45°	0,8 (@1 bar)	8,0	8,5 (@1 bar)	1PM.021.30.80
2,0	60°	0,8 (@1 bar)	8,0	8,5 (@1 bar)	1PM.021.30.40
2,0	90°	0,8 (@1 bar)	8,0	8,5 (@1 bar)	1PM.021.30.81
2,6	45°	1,00	10,0	10,0	1PM.021.30.82
2,6	60°	1,00	10,0	10,0	1PM.021.30.83
2,6	90°	1,00	10,0	10,0	1PM.021.30.84
3	45°	1,20	12,0	12,0	1PM.021.30.85
3	60°	1,20	12,0	12,0	1PM.021.30.22
3	90°	1,20	12,0	12,0	1PM.021.30.86
3,7	45°	1,40	14,0	14,0	1PM.021.30.87
3,7	60°	1,40	14,0	14,0	1PM.021.30.88
3,7	90°	1,40	14,0	14,0	1PM.021.30.89



LEADING SPRAY TECHNOLOGISTS



NOZZLES



LANCES



HEADERS



CONTROLS



SYSTEMS

**Patented**



Lechler GmbH  
 Precision Nozzles • Nozzle Systems  
 P.O. Box 13 23  
 72544 Metzingen / Germany  
 Phone: +49 (0) 71 23 962-0  
 Fax: +49 (0) 71 23 962-333  
 E-Mail: info@lechler.de  
 Internet: www.lechler.de

## BilletCooler - Oval Cone Standard Version

### The problem

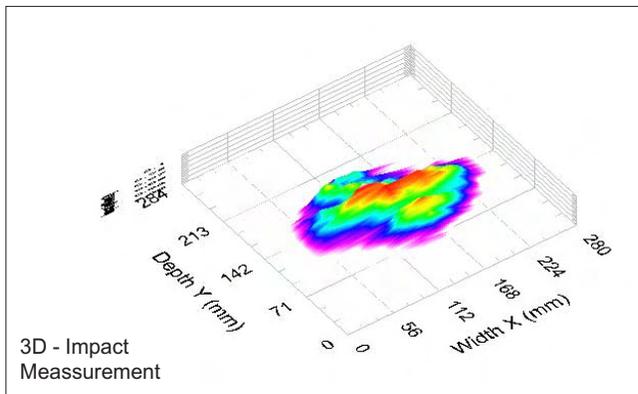
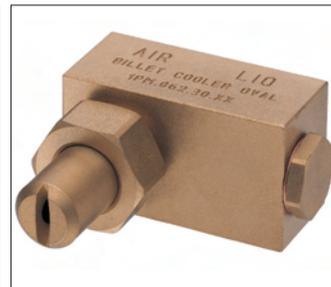
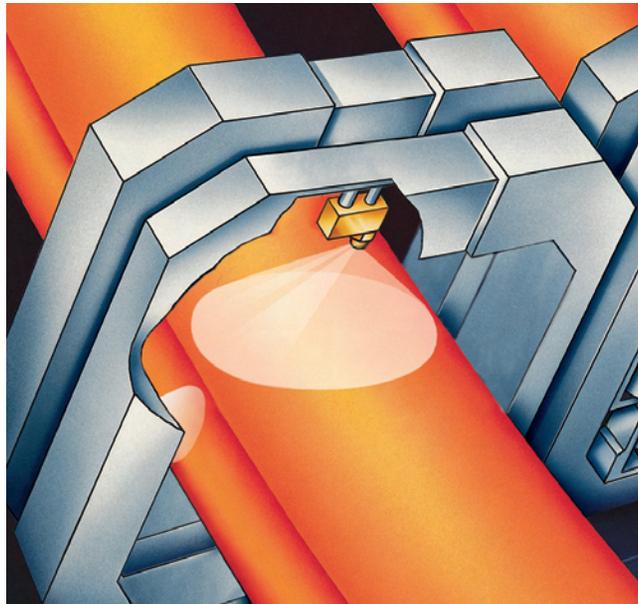
When air mist cooling becomes necessary for a billet or bloom caster flat jet nozzles may not always be the best choice. This is especially true where the formation of Halfway Cracks is experienced.

This type of cracks have shown to be caused by reheating of the surface of the strand after it has passed the sharp heat extraction zone beneath a spray jet. During this reheating process the surface expands and imposes a tensile strain on the interior, hotter and hence weaker regions of the solid shell which then can crack. The use of flat jet nozzles intensifies this effect. Full cone nozzles provide a homogenous cooling over an extended surface area.

These two spray patterns are the standard for single fluid water secondary cooling systems, however there has unfortunately not been an adequate version using air mist. Common full cone air mist nozzles show quite unstable spray performances, very high air consumptions and a tendency to clog very easily.

### The solution

BilletCooler full or oval cone air mist nozzles. With this new nozzle generation it is now possible to utilise air mist cooling also in billet and bloom casters as effectively as in slab casters.



The compact block design allows mounting either on horizontal spray rings but also on vertical nozzle headers. A turn down ratio as wide as 1 : 10 is standard at water pressures between 0,5 (1,0) and 7 bar at 2 bar air constant.

Nominal standard spray angles are 60° x 30°, 90° x 30° and 90° x 45° (spray width x spray thickness).

Free passages approximately three times larger than before makes the BilletCooler a real non clogging nozzle.

### The application

- Billet and bloom casters for higher steel grades such as stainless steels, special spring steel, tire cord steels etc. require more sophisticated cooling systems with higher turn down ratios and often smaller flow rates than hydraulic water nozzles can offer.
- Narrow face cooling in slab casters in the foot roll / top zone segment.
- Wide face cooling in slab casters with support grids in the top zone below the mould.

### The benefits

- High turn-down ratio (min./max. flow rate) 1:10 (max. 1:14) for high flexibility and extended product (steel grade) mix. reduces the number of different nozzle types in the machine.
- Compressed air consumption reduced by appr. 40% for low investment & operation costs
- High Heat Transfer Coefficient (HTC) for high casting speeds
- Compact design ideal for spray rings and vertical headers.
- Plate connection for easy and maintenance friendly mounting.
- Large free passages prevent clogging for high operation safety with improved plant availability.
- Successfully installed in more than 30 casters worldwide.
- Reduced maintenance costs.

LEADING SPRAY TECHNOLOGISTS



NOZZLES



LANCES



HEADERS



CONTROLS



SYSTEMS

**Patented**



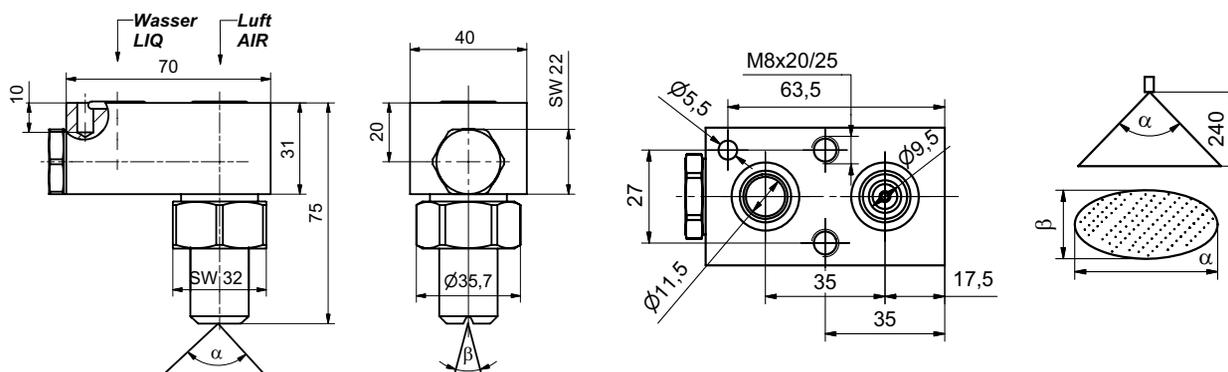
Lechler GmbH  
 Precision Nozzles • Nozzle Systems  
 P.O. Box 13 23  
 72544 Metzingen / Germany  
 Phone: +49 (0) 71 23 962-0  
 Fax: +49 (0) 71 23 962-333  
 E-Mail: info@lechler.de  
 Internet: www.lechler.de

## BilletCooler - Oval Cone Standard Version

### BilletCooler Oval (Oval Full Cone)

		Min. standard water flow at 0,5 bar water pressure (if not other mentioned)	Max. standard water flow at 7 bar water pressure (if not other mentioned)	Max. standard air flow at 0.5 bar water pressure (if not other mentioned)	Nozzle Code
All values at 2 bar constant air pressure					
Size	Spray angle	l / min	l / min	Nm <sup>3</sup> / hr	
0,8	60° x 30°	0,4 (@ 1 bar)	3,0 (6 bar)	3,0 (@ 1 bar)	1PM.074.30.00
0,8	90° x 30°	0,4 (@ 1 bar)	3,0 (6 bar)	3,0 (@ 1 bar)	1PM.074.30.01
0,8	90° x 45°	0,4 (@ 1 bar)	3,0 (6 bar)	3,0 (@ 1 bar)	1PM.074.30.02
0,9	60° x 30°	0,25	3,6	3,6	1PM.074.30.04
0,9	90° x 30°	0,25	3,6	3,6	1PM.074.30.05
0,9	90° x 45°	0,25	3,6	3,6	1PM.074.30.06
1,25	60° x 30°	0,50	5,1	4,6	1PM.074.30.08
1,25	90° x 30°	0,50	5,1	4,6	1PM.074.30.09
1,25	90° x 45°	0,50	5,1	4,6	1PM.074.30.10
1,7	60° x 30°	0,60	6,70	6,40	1PM.074.30.12
1,7	90° x 30°	0,60	6,70	6,40	1PM.074.30.13 *)
1,7	90° x 45°	0,60	6,70	6,40	1PM.074.30.14
2	60° x 30°	0,85	8,30	7,70	1PM.074.30.16
2	90° x 30°	0,85	8,30	7,70	1PM.074.30.17
2	90° x 45°	0,85	8,30	7,70	1PM.074.30.18
2,5	60° x 30°	1,05	10,50	9,70	1PM.074.30.20
2,5	90° x 30°	1,05	10,50	9,70	1PM.074.30.21
2,5	90° x 45°	1,05	10,50	9,70	1PM.074.30.22
3	60° x 30°	0,80	12,2	12,4	1PM.074.30.24
3	90° x 30°	0,80	12,2	12,4	1PM.074.30.25
3	90° x 45°	0,80	12,2	12,4	1PM.074.30.26

\*) already ordered by no. 1PM.062.30.05



Rev. 05 / 2009

LEADING SPRAY TECHNOLOGISTS



NOZZLES



LANCES



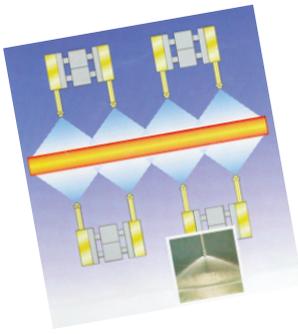
HEADERS



CONTROLS



SYSTEMS



Lechler GmbH  
 Precision Nozzles • Nozzle Systems  
 P.O. Box 13 23  
 72544 Metzingen / Germany  
 Phone: +49 (0) 71 23 962-0  
 Fax: +49 (0) 71 23 962-333  
 E-Mail: info@lechler.de  
 Internet: www.lechler.de

## MasterCooler SMART® The air mist nozzle for every slab caster

### MasterCooler SMART

The air mist nozzles are now equipped with a plate bolted vertically onto adaptor plates. Small diameter fluid feed pipes are no longer necessary. All nozzles are mounted outside of the framework at the rear side of the segment with only the nozzle pipe, carrying the spray tip, reaching down to the spray position. A very rigid header pipe and a nozzle self alignment is the result.

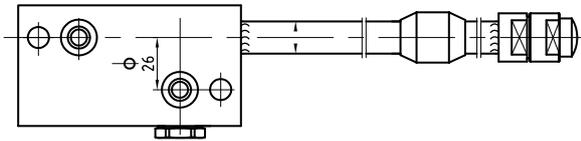
The nozzle spray position is always secured. A "Hoseless" Fluid supply system becomes also possible.

The mixture between compressed air and water takes place away from the hot zone inside the mixing chamber which is an internal part of the vertical plate. Hence, only one single nozzle pipe, exempt of any restrictions, supplies the premixed fluids to the nozzle tip.

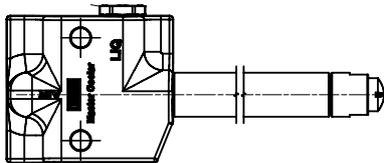
Nozzle staggering between the roller gaps within one segment becomes much easier since different nozzle positions can be served from only one header pipe manifold. Nozzle staggering is one method to equalize the water distribution along the strand in length direction with the intention to eliminate surface defects and cracks.

Nozzle parameters such as water and air flows, spray angle, extension pipe length and connection plate details are customized to the requirements of each individual project.

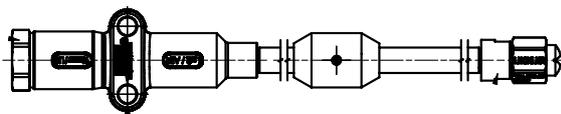
### For Danieli Slab Casters



### For SMS-Demag Slab Casters



### For Siemens-VAI Slab Casters



LEADING SPRAY TECHNOLOGISTS



NOZZLES



LANCES



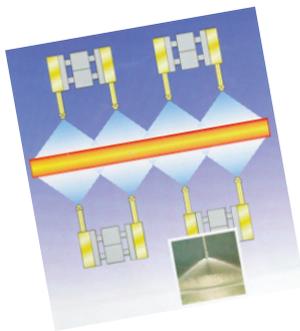
HEADERS



CONTROLS



SYSTEMS



Lechler GmbH  
 Precision Nozzles • Nozzle Systems  
 P.O. Box 13 23  
 72544 Metzingen / Germany  
 Phone: +49 (0) 71 23 962-0  
 Fax: +49 (0) 71 23 962-333  
 E-Mail: info@lechler.de  
 Internet: www.lechler.de

## MasterCooler SMART® The air mist nozzle for every slab caster

### Reference List MasterCooler Smart

1. Hüttenwerke Krupp Mannesmann HKM / Germany ; 2-Strand SMS-Demag slab caster
2. IPSCO / USA ; 1-Strand VAI medium slab caster 3.500mm wide
3. Sabolarie / Italy ; 1-Strand Danieli thin slab (pilot)caster
4. Sidmar / Belgium ; 2-Strand Danieli slab caster
5. Salzgitter / Germany ; 1-Strand MDH slab caster (Lechler revamp) Machine No.1
6. Al Ezz / Egypt ; 1-Strand Danieli thin slab caster
7. Tangshan / China ; 1-Strand Danieli thin slab caster (No. 1 strand)
8. Taiyuan / China ; 1-Strand Danieli slab / bloom caster
9. Panzihua / China ; 1-Strand Danieli slab caster
10. POSCO-Pohang / Korea ; CCP2/2 ; 2-Strand slab caster (POSMEC/Lechler revamp)
11. Rautaruukki / Finland ; 2-Strand VAI slab caster (Nozzle revamp Raut./Lechler)
12. POSCO-GY / Korea ; CCP1/1; 2-Strand VAI slab caster (MasterCooler SMART Cartridge)
13. Imatra / Finland ; 2-Strand MDH bloom caster (SMS-Revamp with MasterCooler Smart & BilletCooler)
14. Aceralia-Arcelor / Spain ; 1-Strand SMS-Demag Slab Caster (Lechler revamp)
15. Shaogang / China ; 1-Strand Danieli medium slab caster 3.500mm wide
16. Tangshan / China ; 1-Strand Danieli thin slab caster (No. 2 strand)
17. Salzgitter / Germany ; 1-Strand SMS-Demag slab caster Machine No.3
18. Benxi 1 / China ; 1-Strand Danieli thin slab caster
19. Benxi 2 / China ; 1-Strand Danieli thin slab caster
20. Xinyu China ; 1-Strand Danieli slab caster
21. POSCO-PH / Korea ; CCP2/1; 2-Strand VAI slab caster
22. POSCO-GY / Korea ; CCP2/4; 2-Strand VAI slab caster
23. Alpha Steel / England ; 1-Strand Danieli slab caster
24. Assow Stal / Ukraine ; 2-Strand NKMZ slab caster
25. Assow Stal / Ukraine ; 2-Strand Danieli slab caster
26. ESSAR Steel / India ; 1-Strand SMS-Demag Slab Caster No.1
27. ESSAR Steel / India ; 1-Strand SMS-Demag Slab Caster No.2
28. ESSAR Steel / India ; 1-Strand SMS-Demag Slab Caster No.3
29. Russia ; 1-Strand STB Slab Caster
30. Isdemir / Turkey ; 2-Strand SMS-Demag slab caster
31. Isdemir / Turkey ; 2-Strand SMS-Demag slab caster
32. Bao Steel / China ; 2-Strand Danieli slab caster
33. National Steel / Iran ; 1-Strand Danieli thin slab caster
34. Tonghua / China ; 1-Strand Danieli thin slab caster (No. 1 strand)
35. Stomana / Bulgaria ; 1-Strand Danieli slab caster
36. Arcelor Dunk. / France ; 2 Strand Danieli slab caster (CC 23)
37. OMK / Russia ; 1-Strand Danieli slab caster
38. Bhushan / India ; 2 Strand SMS-Demag slab caster
39. Amur Steel / Russia ; 2 Strand SMS-Demag slab caster
40. Handan Steel / China ; 2 Strand Danieli slab caster
41. Handan Steel / China ; 2 Strand Danieli slab caster
42. Baotou Steel / China ; 2 Strand Danieli slab caster
43. POSCO / Korea ; Concast Bloom Caster
44. Tonghua / China ; 1-Strand Danieli thin slab caster (No. 2 strand)
45. JSW / India ; 2 Strand SMS-Demag slab caster
46. Arcelor Dunk. / France ; 2 Strand Danieli slab caster (CC 22)
47. Arcelor Fos sur Mer / France ; 2 Strand Danieli slab caster (CC 23)
48. Lipetsk / Russia ; 2-Strand NKMZ slab caster
49. Shougang Jingtang / China ; 2 Strand Danieli slab caster
50. Shougang Jingtang / China ; 2 Strand Danieli slab caster
51. JSW / India; VAI Caster No.3 (Lechler revamp)
52. Severstahl / Russia; Seg.0 (Lechler revamp)
53. AHMSA Caster No.3 / Mexico; (Lechler revamp)
54. DONGBU / Korea; Danieli Slab Caster
55. MECEL / Russia; Danieli Slab Caster
56. Tokyo Steel / Japan; SMS Slab Caster
57. Lianyuan / China; Danieli Slab Caster
58. POSCO CEM Caster / Korea; Danieli Thin Slab Caster
59. Mobaraceh / Iran; SMS Slab Caster
60. ESSAR / India; Caster Nr.4 SMS/Corus Slab Caster revamp
61. Verona Steel / Italy; STB Slab Caster

LEADING SPRAY TECHNOLOGISTS



NOZZLES



LANCES



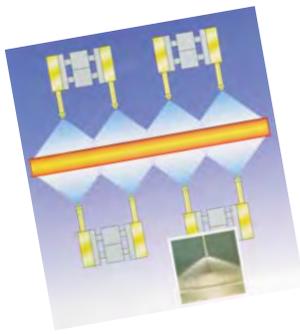
HEADERS



CONTROLS



SYSTEMS



Lechler GmbH  
 Precision Nozzles • Nozzle Systems  
 P.O. Box 13 23  
 72544 Metzingen / Germany  
 Phone: +49 (0) 71 23 962-0  
 Fax: +49 (0) 71 23 962-333  
 E-Mail: info@lechler.de  
 Internet: www.lechler.de

## MasterCooler SMART® Split Pipe design

### MasterCooler SMART Split Pipe design

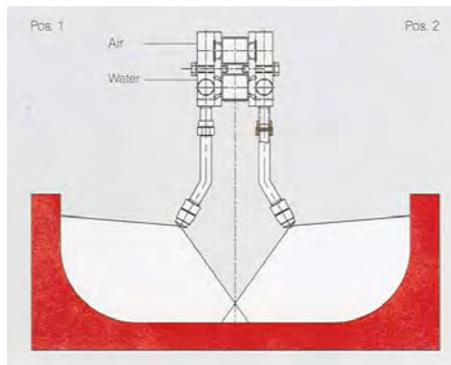
For nozzles with extension pipes longer than appr. 300 mm it is recommendable to install nozzles of the "Split Pipe" version allowing to separate the front part carrying the nozzle tip and nut only. The nozzle's vertical plate together with the remaining part of pipe can be retained. The position of the joint between the two pipe ends can be designed as per request. A self aligning design also secures the correct spray direction at this point. A cost saving feature interesting enough especially for top segments near the mould. In case of a break out only the extension pipe with the tip has to be replaced.



### Beam-blank casters

Depending on the beam-blank dimensions complicated header pipes, small specially bent fluid feed pipes and a fluid distributor have to be individually designed to accommodate standard air mist nozzles. Correct nozzle alignment, mounting and maintenance is difficult, time consuming and expensive.

The nozzle and header pipes with the vertical plate connection are also an ideal solution for beam-blank casters. The advantages described above are also true here. The bends of the nozzle extension pipes can be made to suit. With the aid of the "Split pipe" design the two nozzles on either side can be identical with the front pipe turned by 180°.



Header design with square air and water pipes for MasterCooler SMART and Split Pipe design. Two nozzle positions with only one nozzle type. Split extension pipe offset by 180°.

LEADING SPRAY TECHNOLOGISTS



NOZZLES



LANCES



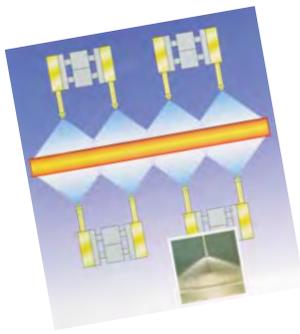
HEADERS



CONTROLS



SYSTEMS



Lechler GmbH  
 Precision Nozzles • Nozzle Systems  
 P.O. Box 13 23  
 72544 Metzingen / Germany  
 Phone: +49 (0) 71 23 962-0  
 Fax: +49 (0) 71 23 962-333  
 E-Mail: info@lechler.de  
 Internet: www.lechler.de

## MasterCooler SMART® Split Pipe design

In modern slab casters a combination of different nozzle types are installed. They can be different in flow rate / size, spray angle and in extension pipe shape. In order to prevent misassembly Lechler offers a variety of different shapes of the extension pipe / nozzle joints.

Shapes allowing a 180° turn for beam-blank caster as described on the front page are possible (Photo 1). Other shapes only allow assembly in a position making in 100% failure proof (Photo 2). The joint can be positioned along the pipe on request. The hex size of the joint depends on size and, hence the pipe diameter of the nozzle. The joints shown guarantee a very rigid and durable connection (Photo 3).

### The special features:

- Only extension pipe needs to be replaced after a break out.
- Very rigid and durable connection.
- For beam-blank casters one nozzle type can serve two nozzle positions.
- Failure proof system due to a variety of the different joint shapes.

### The benefits:

- Reduced maintenance costs.
- Improved operation safety.
- Reduced complexity of stock logistics due to reduced number of nozzles types in case of beam-blank casters.



Photo 1



Photo 2



Photo 3

Split Pipe

LEADING SPRAY TECHNOLOGISTS



NOZZLES



LANCES



HEADERS



CONTROLS



SYSTEMS

# APPLICATION OF MODERN SECONDARY COOLING TECHNOLOGY IN CONTINUOUS CASTING OF STEEL

Mr. Ray Boyle  
Lechler Ltd., UK

Mr. Juergen Frick  
Lechler GmbH, Germany

**Abstract :** Continuous casting machines are now required to cast a wide range of steel grades while maximising production output. Consistent production of prime quality product requires increased operational and maintenance flexibility of the caster so that the optimum casting parameters can be maintained for each steel grade. This flexibility extends not only to the machine elements and control systems, but also to the secondary cooling system and demands more efficient and reliable spray cooling. Attentive design of secondary cooling systems, through cooling zone positioning, nozzle layout, nozzle selection and the use of appropriate secondary cooling control systems can provide these requirements. Minimum down time for maintenance is a key factor in maximising caster production; the use of the latest piping header systems and nozzle mounting arrangements can contribute to minimum secondary cooling maintenance. These header systems provide a rigid and self-aligning mounting for the nozzle, ensuring both nozzle alignment and maintenance accessibility.

## 1 INTRODUCTION

Continuous casting machines are now required to cast a wide range of steel grades, in particular slab casters must cast steels ranging from ULC and low carbon grades to high carbon and high quality pipeline grades. This must be achieved while maximising production output.

Consistent production of prime quality product requires increased operational and maintenance flexibility of the caster so that the optimum casting parameters can be maintained for each steel grade. This flexibility extends not only to the machine elements and control systems, but also to the secondary cooling system and demands more efficient and reliable spray cooling.

Of particular concern when designing a secondary cooling system are: -

- Steel grades to be cast and their casting speeds.
- The roll support geometry and machine segment layout.
- Ease of maintenance.
- Secondary cooling control systems.

This paper focuses on the design of a secondary cooling system that uses the latest nozzle technology to fulfil the production requirements of today's casters.

Unlike in the early days, the layout of the secondary spray cooling system is one of the first steps when a new continuous casting machine is designed, or when an existing machine undergoes a major revamp.

## 2 NOZZLE LAYOUT

A good nozzle layout is paramount in fulfilling the operational and production requirements.

It is essential that nozzle arrangements produce an even heat removal across the strand while maintaining a stable spray pattern. Spray collision with support rolls should be avoided as this will result in inefficient use of spray water and a reduction in heat transfer.

Generally multi-nozzle layouts should be the preferred arrangement. In the final area of solidification of non critical steel grades, typically the horizontal section of curved casters, it is possible to reduce the number of nozzles in a roll gap to one or two as this is a less critical area for solidification. The staggering of nozzle pairs in consecutive roll gaps, see Figure 1 will ensure even surface temperatures.

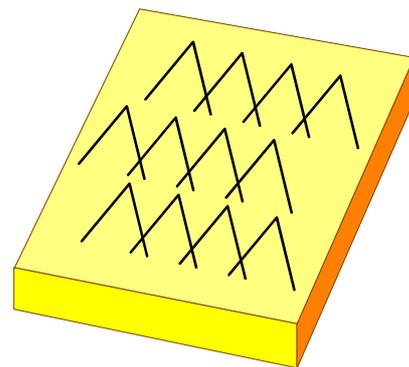


Fig.1 Staggered nozzle arrangement

Spray width control can be achieved with a multi-nozzle configuration. In a multi-nozzle arrangement the outermost nozzles are systematically turned off in relation to the strand width as shown in Figure 2 where a nozzle layout which alternates the number of nozzles in consecutive roll gaps can be used. If a more finer control is required then an inline arrangement as shown in Figure 3 can be used.

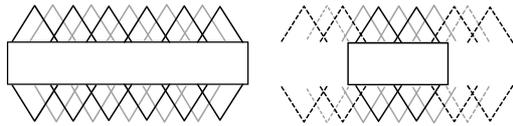


Fig. 2 Spray width control –alternating nozzles

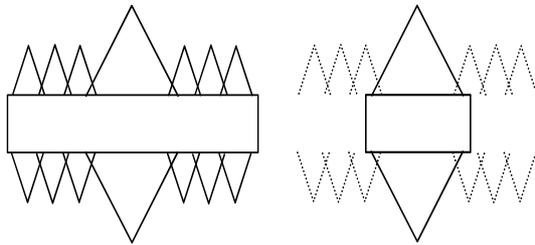


Fig. 3 Spray width control-inline nozzles

Heat removal from the strand is not only a function of spray cooling; other mechanisms are also prevalent, for example heat removal by the support rolls.

Heat removed by rolls can have a significant effect on the strand surface temperature and strand solidification conditions. If the heat removed by rolls is considered even across the strand width together with even heat removal by the sprays then ideal solidification conditions as shown in Figure 4 should exist.

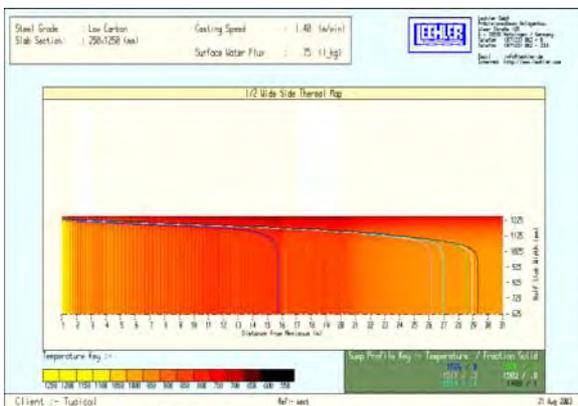


Fig. 4 Even heat removal by rolls and sprays

### 3 NOZZLE SELECTION

Nozzle selection can only occur after derivation of the solidification profiles, the cooling zone layout and the nozzle layout. The heat extraction required to achieve the solidification profiles is converted into cooling zone water flows using nozzle heat transfer coefficients. The specific nozzle flows can then be derived from the maximum water flow associated with each cooling zone.

Prior to final nozzle selection, operational factors must be considered, these factors include: -

- Spray water temperature compensation factor – heat extraction capability reduces with increasing water temperature, see Figure 5 and can lead to both operational and quality problems. Typically this factor would be applied during hot summer periods.
- Increased flow rate on the outer radius – this is used to equalise cooling on both the inner and outer strand faces by compensating for the gravitational effect on the outer radius.
- Safety factors – any allowance above the calculated water flows

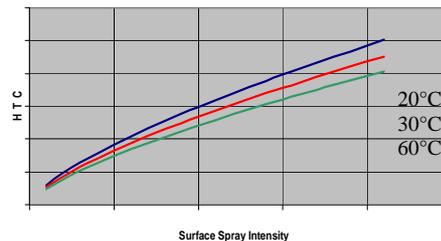


Fig.5 Effect of spray water temperature on HTC

It is important for today's caster designers to have access to nozzles which have high turndown (control range, min./max. water flow) capabilities for not only operational reasons but also to minimise the nozzle varieties in one particular machine. Both maintenance and inventory managers appreciate this effort.

Latest achievements in air mist nozzle research and development are now providing designs with turn down ratios wider than ever before and with lower air consumption. The flow diagram in Figure 6 of a Lechler Mastercooler air mist nozzle shows that a turn down ratio of more than 1:20 at a constant air pressure of 2.5(bar) is not impossible between water pressures of 0.5(bar) and 7(bar).

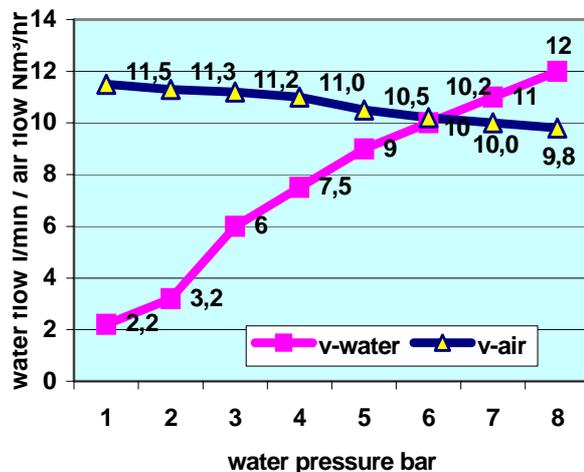


Fig. 6 Pressure flow diagram of Mastercooler air mist nozzles

#### 4 NOZZLE DESIGN

Once the secondary cooling system layout is completed and the mechanical design of the segments is known, it is the spray nozzle manufacturers task to design nozzles which provide a uniform water distribution across the strand surface and over the entire turn down ratio. Tolerances of  $\pm 15\%$  from the mean value can be achieved with a multi nozzle arrangement at water pressures between 1.0 and 7.0 bar. Figure 7 shows the water distribution measurements of a twin nozzle arrangement. The nozzle pitch is 400(mm), the spray height 200(mm), and the air pressure 2(bar) constant and 7(bar) water pressure.

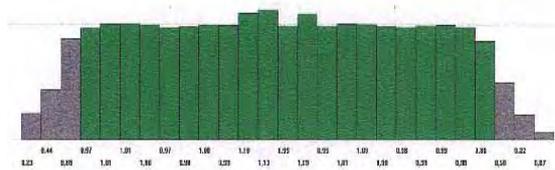


Fig.7 Uniform water distribution measurement

#### 5 MAINTENANCE

Because of their internal mixture, air mist nozzles require two separate feed pipes for compressed air and water. Until recently small diameter pipes were used to feed both the fluids and to hold the nozzles in place. Only in special cases, where one fluid was fed directly by a hose, additional supports were provided.

The conventional air mist nozzles mounted on these small pipes are hidden inside the segment framework as shown in Figure 8.

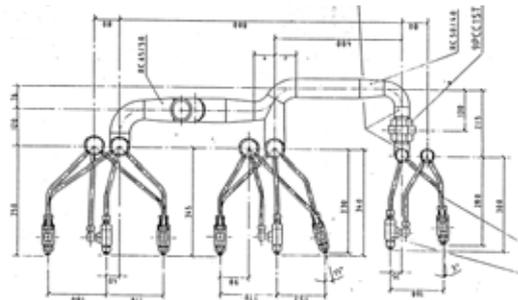


Fig. 8 Header manifold old design with many small feed pipes

Having the nozzles mounted so close to the strand makes maintenance (cleaning or adjustment) impossible unless the segment is removed from the machine. In the case of a break out nozzles must be completely replaced, which is very costly.

Strand surface defects can often be traced back to misaligned spray nozzles. Header pipes such as shown are one source of such misalignments. The many small air and water pipes are often out of position due to mechanical impact or thermal

reasons. The large number of small, individually bent pipes, are also expensive to manufacture.

Within the last 5 years the vertical segment piping developed for the Lechler Mastercooler air mist nozzles with vertical square header pipes has almost become an industry standard design. The air mist nozzles now equipped with plates are bolted vertically onto adapter plates as shown in Figure 9.

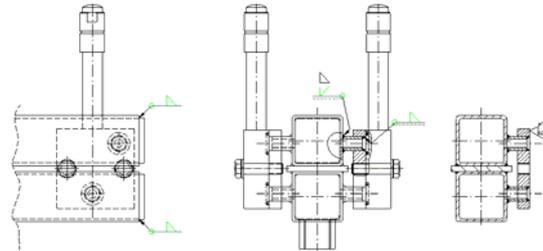


Fig.9 Mastercooler mounted on vertical plate and square pipe manifold

All nozzles are mounted outside of the framework at the rear side of the segment with only the nozzle pipe, carrying the spray tip, extending down to the spray position. A very rigid header pipe giving a nozzle self-alignment is the result; the nozzle spray position is always secured. A "Hose less" fluid supply system becomes a standard. Frequent replacement of many expensive water and air hoses is no longer required.

Nozzle staggering between the roller gaps within one segment becomes much easier since different nozzle positions can be served from only one header pipe manifold, see Figure 10.



Fig.10 Staggered Mastercooler nozzles served from one pipe manifold

The nozzles and header pipes with the vertical plate connection are also an ideal solution for beam blank casters with air mist cooling. Instead of a complex manifold only two square header pipes with two nozzles bolted on, are required. The advantages described above are also true

here. The bends of the nozzle extension pipes can be made to suit. With the aid of the "Split pipe" design the two nozzles on either side (Pos. 1 and 2 of Figure 11) can be identical with the front pipe turned by 180°, hence one nozzle type can serve both positions in one gap.

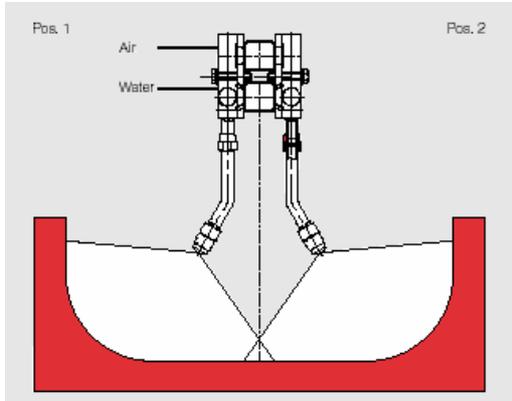


Fig.11 Mastercoolers installed in a beam blank caster

## 6 NEW AIR MIST NOZZLES FOR BILLET AND BLOOM CASTING

When air mist cooling becomes necessary for a billet or bloom caster, flat jet nozzles may not always be the best choice. This is especially true where the formation of Halfway Cracks may be experienced. This type of crack has been shown to be caused by reheating of the strand surface after it has passed the sharp heat extraction zone beneath a spray jet. During this reheating process the surface expands and imposes a tensile strain on the hotter and weaker inner material, which can then crack. The use of flat jet nozzles intensifies this effect.

Full cone nozzles or oval cones provide a softer cooling by extracting heat over an extended surface area. These two spray patterns are the standard for single fluid water secondary cooling systems, however there has not been an adequate version using air mist. Common full cone air mist nozzles show unstable spray performances, very high air consumptions and a tendency to clog very easily. Oval cone air mist nozzles are often flat jet nozzles with multi slot orifices. Non uniform spray patterns and the very narrow easy to clog slots, made these nozzles barely more than a compromise.

With the new Lechler Billetcooler Figure 12, a new generation of full and oval cone air mist nozzles it is now possible to utilise air mist cooling in billet and bloom casters as effectively as in slab casters. The compact block design allows mounting both on horizontal spray bars and on vertical "Banana" nozzle headers, Turn down ratios as wide as 1:14 have been achieved at water pressures between 1.0 and

10.0(bar) at 2(bar) air constant. Nominal spray angles for circular full cone nozzles range between 60° and 90°. Free passages with 2.0mm in diameter are approximately three times larger than before for a nozzle size with flows ranging from 0,5(l/min) at 1(bar) water pressure and 5.0(l/min) at 7(bar) water pressure at a constant 2(bar) air pressure.

Extremely critical cooling problems have successfully been solved in a 5-strand bloom machine casting more than 250 steel grades and also critical stainless steel rounds.



Fig. 12 The new Lechler Billetcooler full cone air mist nozzle

## 7 CONCLUSION

The benefits for the user but also for the machine designer described in this paper are well established facts. The most important of them are:

- Reduced incidence of surface defects and crack formation
- Reduced maintenance and operation costs
- Improvement of operation safety
- Enlargement of caster product mix
- Increased caster production

The modern air mist nozzle and header pipe technology can be incorporated into new machines as well as into existing casters for billets, blooms, beam blanks, slabs and thin slabs.

## References

- 1 Jürgen Frick. "USER BENEFITS OF MODERN AIR MIST NOZZLE AND SECONDARY COOLING SYSTEM TECHNOLOGY" 85<sup>th</sup> Steelmaking Conference March 10-13, 2002 Nashville, Tennessee USA
- 2 Jürgen Frick, Roman Haap "Improved Secondary Cooling in Continuous Casting" at XXXII Seminario de Fusao, Refino e Solidificacao dos Metais on May 7<sup>th</sup> & 8<sup>th</sup>, 2001 in Salvador / Brazil

# **AUDITS OF SECONDARY COOLING SYSTEMS IN EXISTING CASTERS AS A METHOD TO ENHANCE PRODUCT QUALITY AND PRODUCTIVITY**

Ray Boyle  
Lechler Ltd.  
Sheffield, S9 2TP / England  
E-mail : rayboyle@lechler.com

Jürgen W. Frick  
Lechler GmbH  
D-72555 Metzingen / Germany  
E-mail : [fju@lechler.de](mailto:fju@lechler.de)

## **Abstract**

Over the life span of a continuous casting machine the requirements in terms of production output, product quality and the range of steel grades may change significantly. Consistent production of prime quality over the extended steel grade range requires an increased operational and maintenance flexibility which can be missing from existing casters. The secondary cooling system is a key technology area and its modification can greatly contribute to increased production, quality and flexibility.

A caster secondary cooling audit is a systematic and structured approach to determine how an existing secondary cooling system, operational practices and process automation data, impact on quality and productivity. The scope of an audit can vary from simply increasing nozzle capacities to a complete redesign of a secondary cooling system.

## **Secondary Cooling Audit**

An audit consists of:

- Benchmarking existing conditions.
- Diagnosing problems.
- Providing solutions.
- Proposal and plan on how to implement process, operational and maintenance improvements so that the required objectives are achieved.

The complex process of continuous casting requires a thorough understanding of the process technology and the environment of a steelmaking plant. Tools such as mathematical solidification models, complete check lists for data collection and standardised audit procedures are essential for efficient project planning.

## **Benchmarking of Existing Conditions**

Establishing and benchmarking existing operational, performance and quality data is at the heart of the audit and provides the foundation from which recommendations can

be made. A site survey is generally performed and detailed information is collected to enable a computer aided analysis to be performed. The comprehensive information required for this analysis includes: machine configuration, mould heat removal, support roll layout and cooling arrangement, cooling zone and nozzle layout, nozzle performance curves, steel grades and casting speeds, cooling practices and both quality and operational problems. This benchmarking analysis ensures that the computer models give a true representation of the actual caster. A typical result of this analysis in the form of a strand surface temperature and solidification profile is shown in Figure 1.

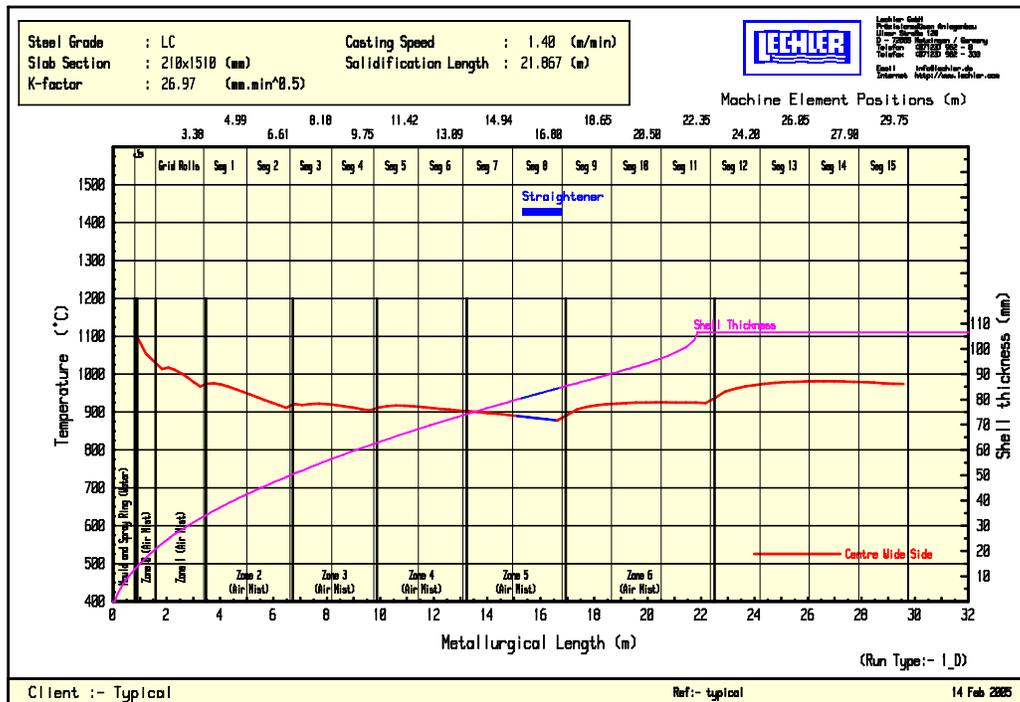


Figure 1 – Strand surface temperature and solidification profile.

## Diagnosing Problems

A key to the success and quality of a caster audit and the subsequent proposal for improvements is the investigation of the problem areas through benchmarking. Here the input of the operators, the maintenance personnel together with the investigation of metallurgical quality and defects is required. Actual strand surface temperature measurement data also helps to analyse and benchmark the existing situation.

Following the benchmarking, a detailed computer analysis of the caster performance with regard to steel grades, casting speeds and secondary cooling is normally performed to identify problem areas and distinguish between defects connected with the secondary cooling system or those caused by other effects.

## Typical Examples of Problem Diagnosis

If a crack defect is detected in a slab at 40mm depth below the surface, then according to the shell thickness growth shown on the right hand axis of figure 1, this defect can be attributed to a problem in segment 1 at a machine element length of approximately 4,5m.

A modern online temperature scanning device was used for monitoring the slab surface temperature on the casting bow prior to entry into the straightener unit. The output of this device indicated an uneven temperature distribution across the slab width. The temperature deviation was approximately 100°C and was visible as stripes on the strand surface at the exit of the machine.

Subsequent analysis showed that the peaks in temperature coincided with the split roll bearing positions; this was confirmed by the computer analysis shown in Figure 2.

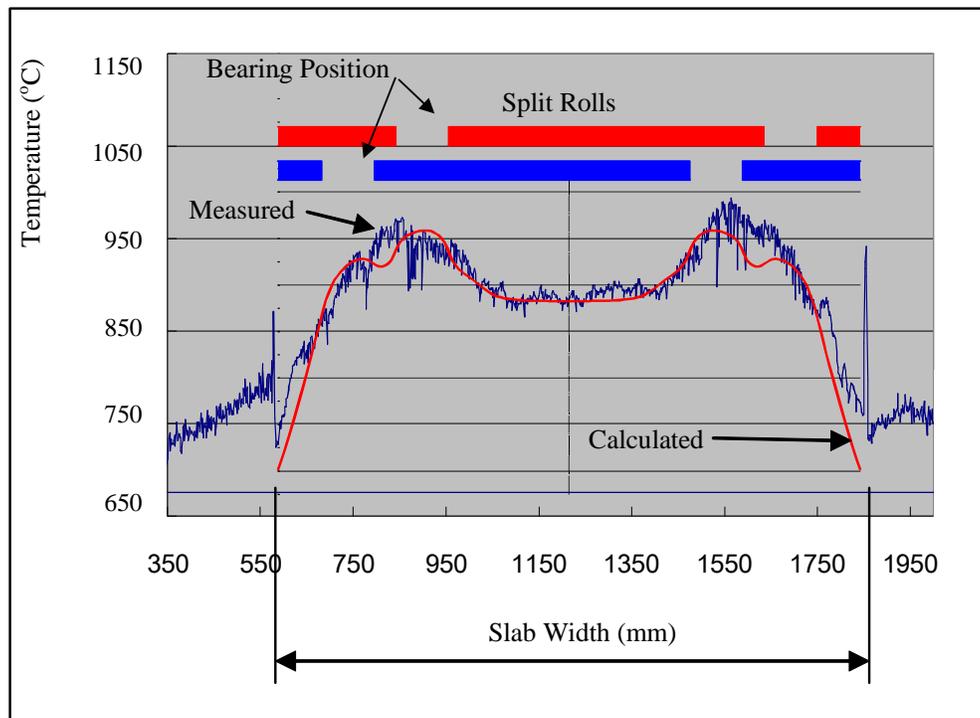


Figure 2 – Strand surface temperature measurement and modelling comparison.

In this case the casting bow is a "one piece" design and although the split roll bearing are offset from roll to roll they are inline down the whole of the casting bow. The reduced heat extraction at the bearing positions produces the "striped pattern" shown for half the slab width in Figure 3. The darker line in the centre of the lighter stripe coincides with the roll overlaps.

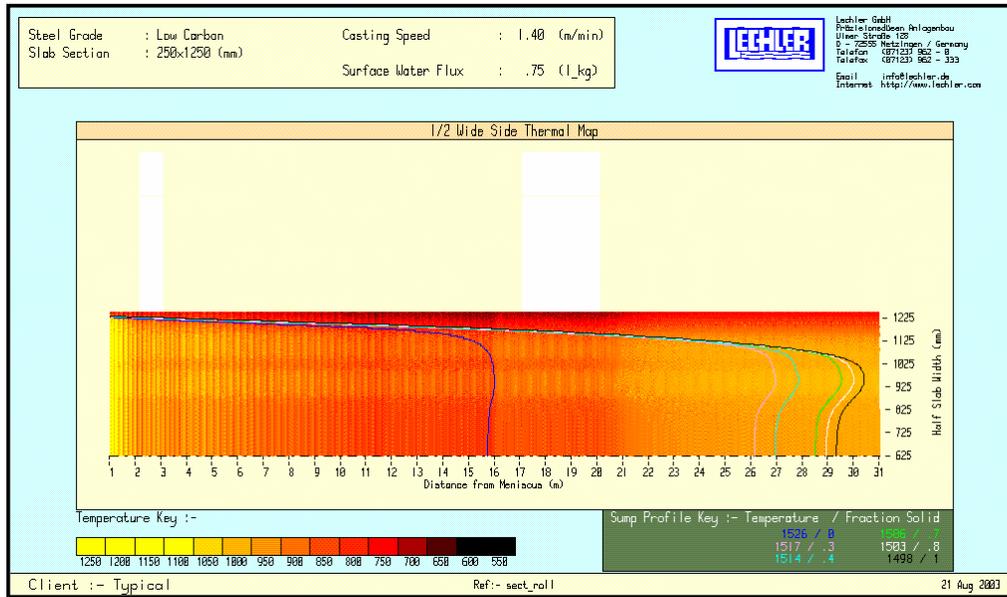


Figure 3 – Surface temperature map of solidification model showing only half of the strand wide side with typical W-Shape crater end.

Figure 3 also clearly indicates that a “W-Shape” crater end profile results from the high surface temperature areas associated with the roller bearings; if soft reduction would be applied for this steel grade then centre line segregation could be expected.

The vertical support girders of the casting bow interfere with the ideal nozzle positions and spray heights (Figure 4); this results in a reduced water density in the non optimal spray overlap area. The nozzle staggering does not completely compensate for this mechanical limitation. This contributes to the effect of the reduced heat removal in the roll bearing area and intensifies the strand surface temperature deviation.

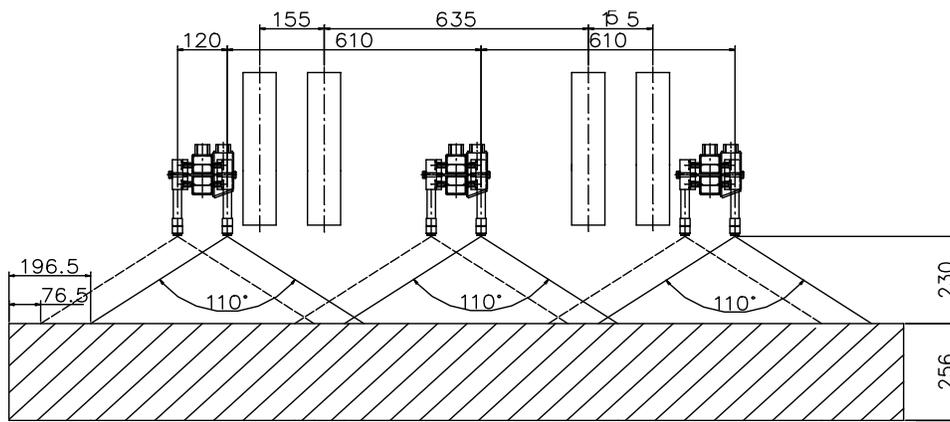


Figure 4 – Nozzle and girder positions.

## On Site Plant Survey

The initial step of a caster audit, before the benchmarking takes place, is to obtain an accurate picture of the real situation by conducting an on site machine survey which includes:

- Physical measurements of existing nozzle positions and spray heights in all segments either, on the caster during stand still or, in the maintenance bay.
- Verification of the water flow tables of the secondary cooling control system for both levels 1 and 2.
- Measurements of the maximum available water flows and pressures of every cooling zone.
- Measurements of the maximum available air flows and pressures.
- Investigation of the cooling water supply temperature.
- Investigation of water and air control instrumentation, filtration and pipe dimensions in segments and machine.
- Investigation of existing emergency water tank and exhaust fan capacities.
- Investigation of existing water treatment, pump and compressor capacities.

In most cases experience has shown that any existing documented data is not usually reliable since changes and modifications may have been made over the life span of a machine. These changes have often been made without updating the documentation. Observation of events, unexpected behaviour, minutes from interviews and meetings as well as digital photographic recordings are also a part of the on site survey. In Figure 5, misaligned and off position air mist nozzles can be seen, the sprays are colliding with support roll so reducing their cooling efficiency.



Figure 5 – Misaligned and off position air mist nozzles.

## Off Site Analysis

The next step of the audit is to analyse and further verify the collected data, an action that is performed off site.

Water flows and in the case of air mist, compressed air flows, together with their related pressures are always the centre of focus. If documented and measured data contradicts, then potential error sources are identified by specific calculations. These include pressure drops, location of bottlenecks caused by instrumentation components or additional fittings and incorrect flow table values in the secondary cooling control systems.

Samples of all existing nozzles are measured in the nozzle laboratory and actual pressure flow diagrams are established for comparison with the plant data. In the case of multi nozzle arrangements, water spray distribution measurements are performed over the entire control ratio (minimum to maximum water flows) under plant conditions in terms of spray height and nozzle pitch.

Figure 6 shows a poor spray water distribution resulting from an excessive (too large) nozzle pitch in the centre of a four nozzle per roll gap layout. Here the headers were not manufactured as per drawing and modifications had also been made to the segment without reference to the nozzle positions.

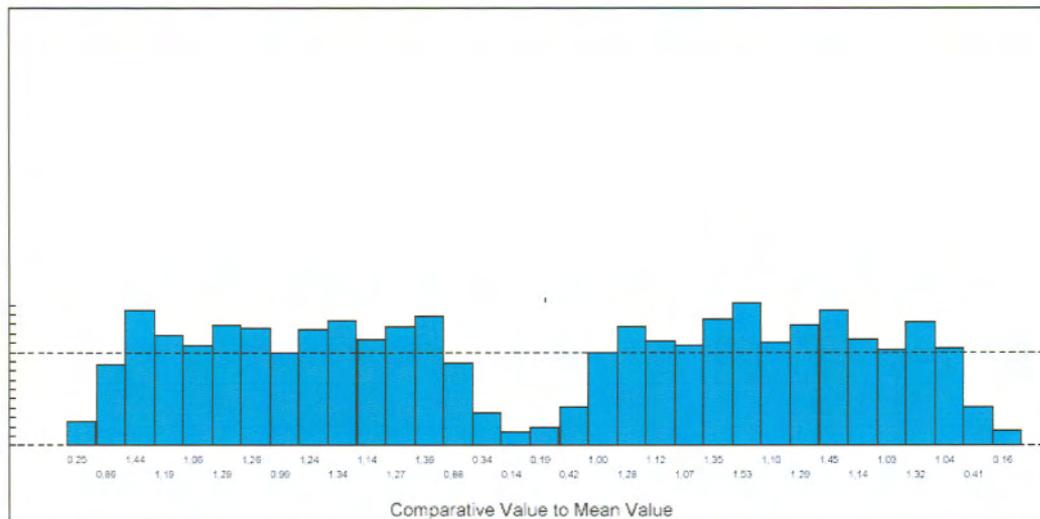


Figure 6 – Poor spray water distribution caused by false nozzle pitch in the centre.

The problem of transverse surface and corner cracking associated with Micro Alloyed Steels is often found in older slab casters which have single nozzle arrangement installed in a roller gap. This arrangement always sprays with a constant spray width irrespective of slab width. Depending on the spray characteristic of the installed nozzle, either the strand corner or the centre is overcooled. The cracks are created during bending and straightening when the strand surface temperature is (partly) in the critical low ductility temperature region between 700°C and 950°C (Figure 7). In these casters corner cracking occurs mainly when casting narrow width slabs.

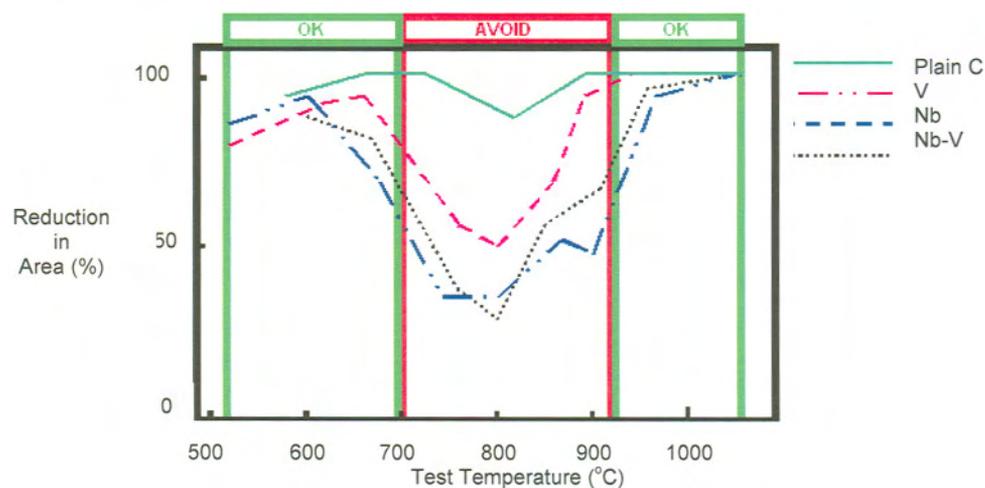


Figure 7 – Steel grade temperature related ductility curves Micro Alloyed Steels.

In an attempt to solve nozzle clogging problems, a twin or a multi nozzle arrangement is sometimes replaced by a single nozzle in a roll gap. This increases the single nozzle size and hence the free internal passages. However, due to the increased spray height which becomes necessary in order to cover the same strand width, the spray footprint on the surface widens and can result in spray collision with the support rolls as shown in figure 8. This reduces the heat transfer significantly because:

- The water flow available to cool the strand surface is reduced.
- The increased spray height reduces the spray impact.
- The wider spray angle reduces the spray impact.

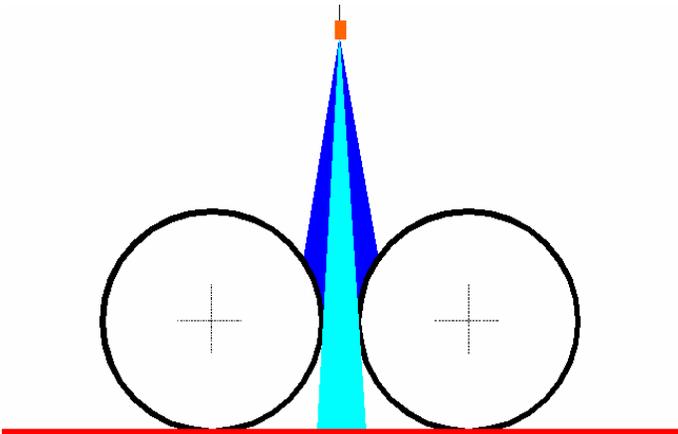
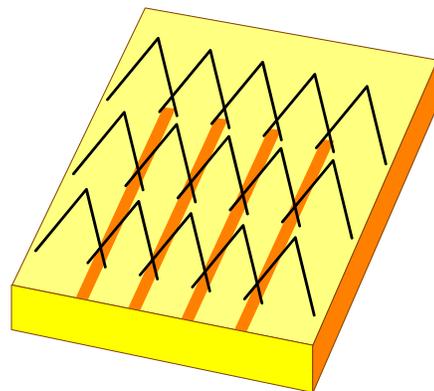


Figure 8 – Spray collision with support rolls.

Multi-nozzle layouts use nozzles with smaller spray angles which produce a more stable spray pattern over their operating range. However, poorly designed and arranged nozzles can produce uneven heat removal particularly in the overlap areas. Consecutive rows of such nozzles can produce “temperature stripes” on the strand surface, which can result in quality problems. See Figures 9 and 10



Figures 9 and 10 – “Inline” nozzle layout causing temperature striping.

Nozzle heat extraction capability reduces with increasing spray water supply temperature as shown in Figure 11 and can lead to both operational and quality problems.

Compensation factors which increase or decrease the spray water flow with respect to supply temperature can be used to eliminate these problems, but they can have a significant effect on the useable water turn down of the nozzle. Addition factors will increase the required maximum nozzle design flow and as such increase the achievable minimum flow, this effectively “over sizes” the nozzle. Water flow turndown during periods when the temperature factors are not applied will be reduced so increasing the risk of overcooling at low casting speeds. This situation becomes more critical for single fluid nozzles because of their inherently limited turndown.

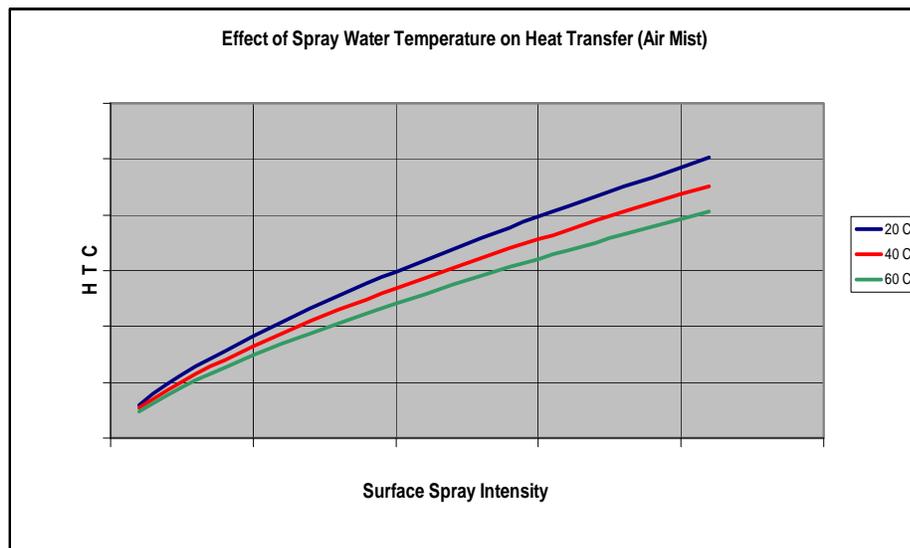


Figure 11 - Effect of spray water temperature on HTC (air mist nozzles).

### Setting the Objectives for a Revamp

There can be a number of reasons for conducting a detailed caster audit. The most common are:

- Identify product quality defects and to eliminate them.
- Improve maintenance friendliness and reduce costs.
- Increase production by increase of casting speeds.
- Change of strand formats and steel grades (product mix).

In most cases it is a combination of all four reasons that determines the objectives for a revamp of the secondary cooling system. It is important that these objectives are clearly defined so as to provide the audit party with a clear focus when preparing the final caster audit report and subsequently, the feasibility study for the revamp.

## **Providing Solutions**

Using the previous analysis and the benchmarking as a basis, modifications to the secondary cooling system are proposed. These modifications are aimed at an economical and operable solution with the objective of achieving the new requirements; again computer analysis is applied to ensure the integrity of the modifications. If necessary the proposal can include modifications to supply pipe work, both on and off the caster, together with control instrumentation and control data.

## **Proposal and Plan**

A comprehensive report is produced and submitted for further discussions and the derivation of an action plan. The report includes:

- Conclusions on existing casting conditions.
- Recommendations and observations with regard to the new objectives, together with proposals on the following areas:-
  - Secondary cooling layout.
  - Nozzle layout and capacities.
  - Maximum and minimum flow rates.
  - Secondary cooling control.
  - Supply pipe work.
  - Control instrumentation.
  - Secondary cooling control and control data.
- Conclusions and recommendations on operational and maintenance practices.
- All vital secondary cooling system utilities.

When proposing modifications which give the secondary cooling system the flexibility to maintain optimum casting parameters, it is necessary to pay careful attention to cooling zone layout and both nozzle positioning and selection. Cooling zone and nozzle layouts must be configured with respect to the steel grades, casting speeds and roll support geometry. In certain cases the actual casting machine segment structure will dictate the nozzle layout in which case the layout may not be ideal but more a compromise. Nozzle selection is dependant on both nozzle layout and the operational characteristics of the caster.

## **Cooling Zone Layout**

An incorrect cooling zone layout can significantly affect caster operation, productivity and product quality.

Cooling zones that are high in the caster should be kept short in length so as to minimise the water pressure head differences within the zone; large pressure head differences will produce uneven cooling over the length of the cooling zone. This will be more apparent at slow casting speeds where generally the spray nozzles are operating close to their minimum water flows and pressures. Short cooling zones also allow better control of surface temperature and solidification in this critical area of the caster; long zones can lead to non ideal temperature profiles.

Micro alloyed steel grades can benefit from spray width control. This is where the actual sprayed width is automatically adjusted in line with the cast width so preventing over spraying of the strand and as such over cooling of the corners and edges. The result is hotter strand corners and edges, which during bending and straightening minimises the risk of corner and transverse surface cracking.

### **Nozzle Layout**

A good nozzle layout is paramount in fulfilling the operational and production requirements of the caster. In designing a nozzle layout, it is not only important to consider the solidification and metallurgical requirements of the steel grades to be cast, but also the behaviour of the nozzles under operational conditions, the machine segment design and the roll support configuration. It is essential that nozzle arrangements produce an even heat removal across the strand while maintaining a stable spray pattern.

### **Conclusion**

An audit as described and the subsequent feasibility study delivers a wide range of benefits by determining the improvements that can be obtained by an upgraded secondary cooling system with improved operation and maintenance practices. The thoroughly documented final report, containing collected and analysed data and a proposal for future improvements through a system upgrade, forms a comprehensive and indispensable tool for decision making and comparison with other plants. An audit also identifies problems and causes which were previously not recognised. The time, efforts and cost of such work is insignificant in comparison with the potential benefits of a properly executed audit which results in an optimised secondary cooling system.

### **References :**

1. Gary Boulton, R.G. Davies, W.J. Edwards, P. Steigler, G.A. Wallace, Auditing Rolling Mills Performance, SEASI Quarterly 2004 Vol 33 No. 1
2. Ray Boyle, Juergen W. Frick, IMPLEMENTATION OF MODERN SECONDARY COOLING TECHNOLOGY IN EXISTING CASTERS, 3<sup>rd</sup> International Conference on Continuous Casting of Steel in Developing Countries, Beijing China, Sept. 2004

## **NEW SECONDARY COOLING SYSTEMS AND PRACTICES**

Juergen Frick – Lechler GmbH, Metzingen, Germany.  
Ray Boyle – Lechler Ltd, Sheffield, United Kingdom.

### **ABSTRACT.**

In order to reduce operational costs, Plants are looking to minimise the number of operational casters by increasing the output of individual machines through increased casting speed. The ability to cast low carbon steels at ever increasing casting speeds, while still being able to cast the more critical steel grades is demanded by Steel Plants, this requires a wider control and performance of the secondary cooling system. New technologies which provide a solution to these problems are now being adopted; these include “Hard-Hard” cooling and various methods of spray width control. “Hard-Hard” cooling is the ability to apply very large quantities of spray water to the slab surface while maintaining acceptable surface temperature levels. New nozzle designs which maximise the spray footprint on the slab surface are required to provide the acceptable surface temperature levels. This new “Hard-Hard” cooling concept, combined with new air mist spray nozzle solutions, allows very intense cooling or “Soft Cooling” depending on the steel grades and formats which are to be cast. The benefits resulting from these new technologies include increased production, reduced investment and operational costs and improved caster operation and better cast quality.

### **KEYWORDS:**

**“Hard-Hard” cooling, intense cooling, soft cooling, air mist spray nozzles, spray width control, variable spray height, nozzle movement systems.**

### **DEFINITION OF “HARD-HARD” COOLING.**

“Hard-Hard” cooling is the ability to apply very large quantities of spray water to the slab surface in the upper cooling zones so as to quickly reduce the slab surface to below 700°C while maintaining acceptable surface temperature levels. This practise requires a totally different nozzle design and nozzle arrangement in the top zone of a slab caster.

### **REASONS FOR “HARD-HARD” COOLING.**

In order to reduce operational costs, Plants are looking to minimise the number of operational casters by increasing the output of individual machines through increased casting speed.

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 turndown.

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.

New technologies which provide a solution to these problems are now being adopted; these include “Hard-Hard” cooling, various methods of spray width control and new nozzle design concepts.

## APPLICATION OF “HARD-HARD” COOLING.

Increasing caster output through increased casting speed for low carbon steel grades, leads to increased solidification length and longer caster support lengths. Inter roll strand bulging and mould level stability, with its associated affect on surface quality, also become more problematic.

In its self “Hard-Hard” cooling cannot totally address the issues of inter roll strand bulging, small roll pitches are also required. These roll pitches require smaller nozzle spray heights which are necessary to prevent wasteful spray collision with the support rolls and results in a multi-nozzle arrangement to provide cooling to the whole of the slab width. The number of air mist nozzles in one roll gap can be double that of a conventional cooling concept.

Normal cooling practices are usually steel grade dependant, the less critical low carbon grades can be cooled harder than the more critical grades as shown in Fig. 1, the cooling intensity is usually reduced as carbon content increases. The main reasons for this are the strand surface temperature drop which occurs within the nozzle spray footprint, together with any subsequent surface reheats.

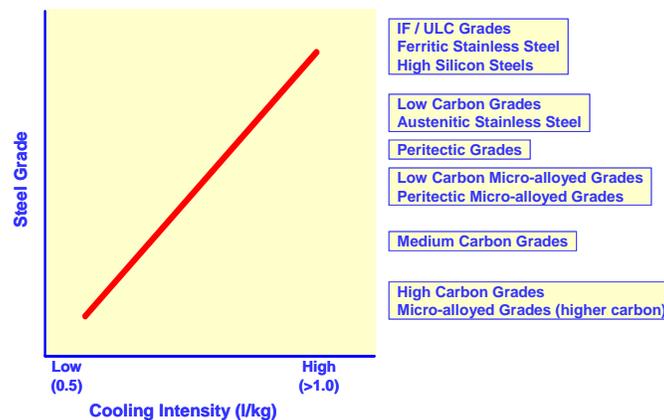


Fig. 1 – Spray cooling intensity versus steel grade.

The minor spray angle of conventional nozzles, also called the spray thickness angle, ranges between 16° and 12° for typical major spray angles of 80° to 120° (wide axis). With spray heights of 200mm to 250mm in the upper cooling zones, a relatively narrow band of footprints

across the strand width exists as shown in Fig.2. The slab surface either side of this narrow band remains almost un-cooled and high temperature fluctuations within the roll gap can occur.

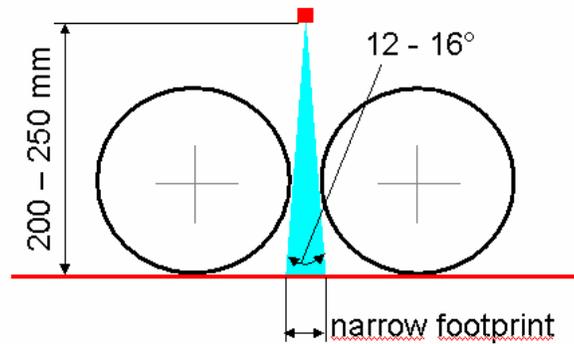


Fig. 2 – Spray footprint for conventional flat fan air mist nozzles.

These surface temperature fluctuations are normally limited by the steel grade to be cast and are typically shown in Fig. 3. Higher surface temperature drops below the spray foot print can lead to slab defects.

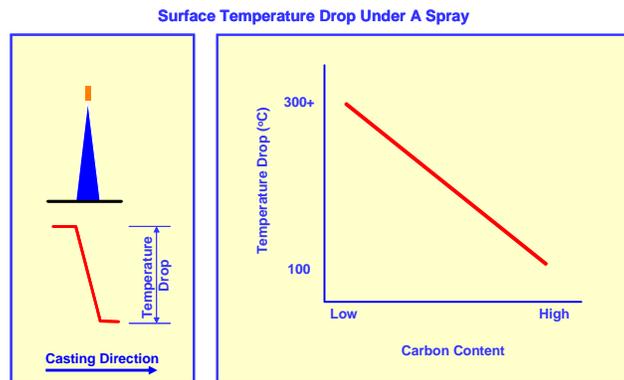


Fig. 3 – Steel grade related surface temperature fluctuations.

Slab defects attributable to secondary cooling can be minimised or avoided using the surface temperature fluctuation limits shown in Fig 3; “Hard-Hard” cooling is a technology developed to address the issues of surface temperature fluctuations and inter roll slab bulging.

“Hard-Hard” cooling technology 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 as shown in Fig.4. These are a result of the relatively

narrow bands of spray footprints across the strand width in the upper cooling zones as shown in Fig.2.

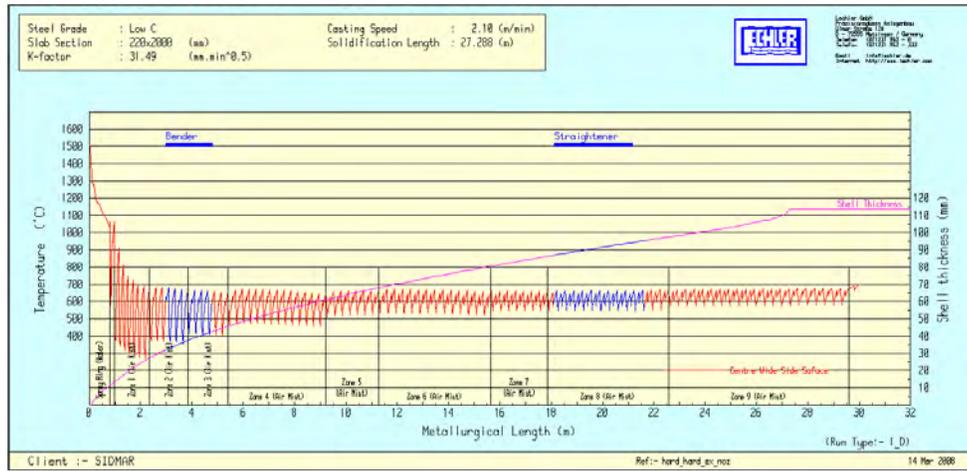


Fig. 4 – Intense cooling profile with conventional flat fan air mist nozzles.

These cyclic fluctuations can be in excess of 450°C in the upper cooling zones of the caster and can result in significant thermal stresses in the cast strand which could lead to the generation of both internal and surface defects.

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 example shown in Fig. 5 uses the same casting parameters and water flows as used for Fig. 4 with the exception of zone 1 which is equipped with the “Hard-Hard” cooling nozzles.

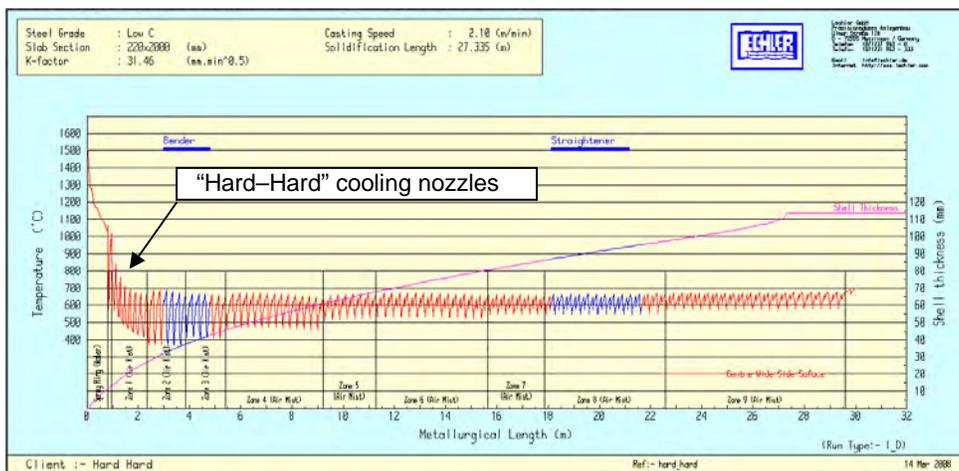


Fig. 5 - Intense cooling profile with Lechler “Hard-Hard” cooling air mist nozzles.

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 (Fig. 6) on the slab surface.

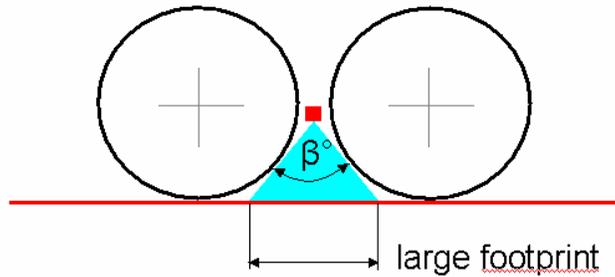


Fig. 6 – Spray footprint for “Lechler “Hard-Hard” cooling air mist nozzles.

#### **“HARD-HARD” COOLING NOZZLE.**

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.

When Lechler developed the “Hard-Hard” cooling air mist nozzle, one of the major design criteria was for a non clogging nozzle tip. This is why Lechler has once more concentrated on the single slot or single orifice principle (Fig. 7) so giving users the benefits of both the highest operational safety and reduced maintenance.

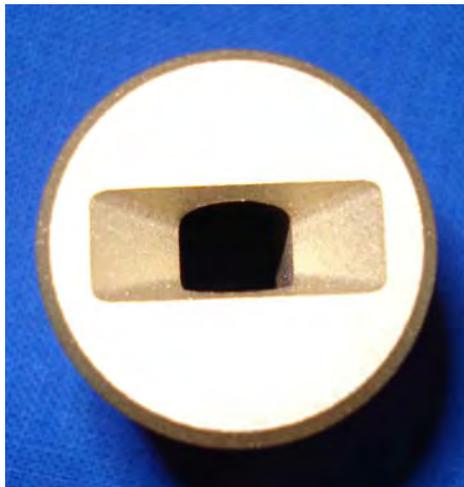


Fig. 7 – Lechler “Hard-Hard” cooling nozzle tip.

These nozzles are also mounted utilising the Lechler MasterCooler SMART method with the vertical plate connection, a system which has become an industry standard after it was successfully applied in the first caster more than ten years ago.

Because of the increased minor spray angle, the nozzles must be positioned very close to the slab surface to prevent spray collision with the support rolls. Typically a spray height of 70 – 100mm is used, in which case the nozzle tip can be below the roll centres, the nozzle tip and the nozzle pipe has therefore been designed to pass between the rolls (Fig. 8).

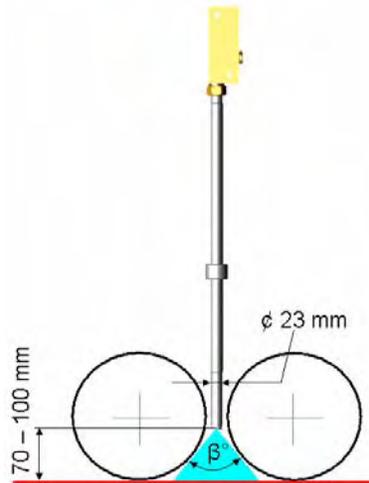


Fig.8 – Roll gap with “Hard-Hard” cooling nozzle.

Normally only zone 1 is fitted with the “Hard-Hard” cooling nozzle and subsequent cooling zones are fitted with normal flat fan air mist nozzles as these are adequate in maintaining the surface temperature at the required level. Spray width control can be incorporated into these zones to prevent overcooling of the slab corners on micro-alloyed steel grades in the case where “soft cooling” is also required.

Spray width control is where the sprayed footprint across the slab width is reduced or increased in line with the slab width and is normally used in casters that produce micro-alloyed steel grades. Various methods exist for spray width control.

## **SPRAY WIDTH CONTROL SYSTEMS WITH MULTI-NOZZLE ARRANGEMENTS.**

Multi-nozzle arrangements can take the form of:

- 1) The nozzles in alternate roll gaps are staggered to prevent overcooling in the spray overlap areas as shown in Fig. 9; this layout is generally used for casters casting a wide range of steel grades which include micro-alloys.

- 2) The nozzles are in line in all roll gaps as shown in Fig. 10; this layout is normally associated with slab casters designed for a product mix focusing more on high quality micro-alloyed plate grades. It can also be found in casters for thin slabs.

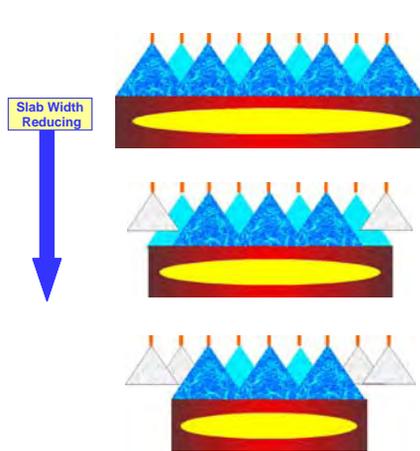


Fig. 9 – Staggered nozzle arrangement.

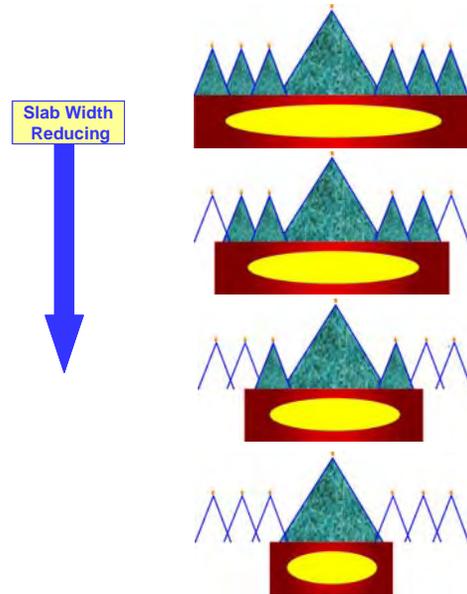


Fig.10 – In line nozzle arrangement.

### WATER FLOW CONTROL CONCEPTS IN MULTI NOZZLE SPRAY WIDTH CONTROL.

In its simplest form, spray width control is achieved using one or two flow control valves to adjust the zone loop water flows together with ON/OFF valves which turn on or off the spray width control nozzles. As the slab width changes the outermost nozzles are automatically turned ON/OFF (Fig.11) and the flow control valves adjust the spray water flow accordingly.

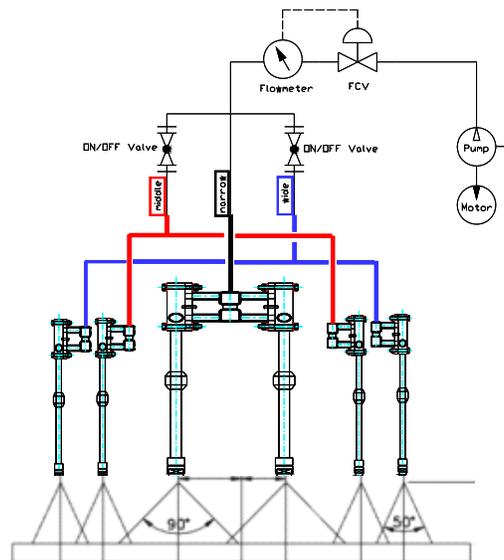


Fig.11 – Simple spray width control system.

This simple and low cost method of control can result in areas of the slab surface towards the slab edges being under cooled, this could lead to localised strand bulging and may contribute to mould level instability.

The effect can become even more severe when the ON/OFF air mist nozzles are of a smaller size than the central nozzles which are used to cover the minimum strand width. Since all the cooling zone nozzles across the strand width, regardless of their size, are being controlled by one flow control valve, it is extremely critical that all the nozzles should have the same control characteristics.

Unfortunately and frequently, not enough attention is paid to this requirement, both in the specification for new machines and also for cost reasons in the purchase of spare nozzles from questionable sources.

The example chosen for Fig. 12 shows an air mist nozzle configuration outlined in Fig.11 with two large nozzles in the centre and smaller nozzles for middle and wide slab width cooling loops. According to the solidification modelling and the cooling curves of the caster HMI level 2 system, the specified nominal flow rate for the centre nozzle is 35l/min at 3.2bar water pressure whereas the smaller nozzles for width control are being specified to spray 15l/min at an identical pressure.

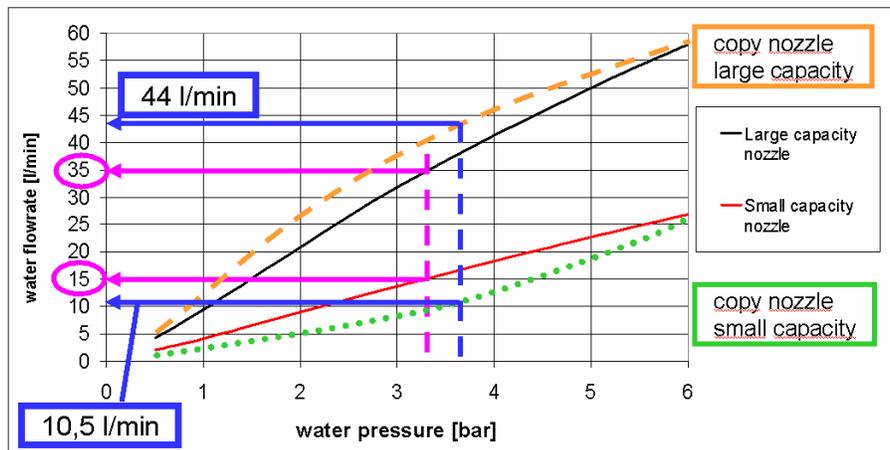


Fig.12 – Authentic and copy nozzle characteristics.

If the actual nozzles installed are not following the specified flow characteristics as described by the curves in Fig.12, heavy over cooling in the centre and under cooling at the edges of the strand can occur.

This effect can be seen in Fig. 13 which shows the cooling water density across the entire strand width based on the nozzle arrangement of Fig.11. The blue columns represent the

desired water density whereas the red columns show the actual water density with 25% more water in the centre region and 30% less than specified under the spray width control nozzles.

This effect is not recognised by the secondary cooling control system since the total cooling zone water flow is correct, even though its distribution across the strand surface is incorrect.

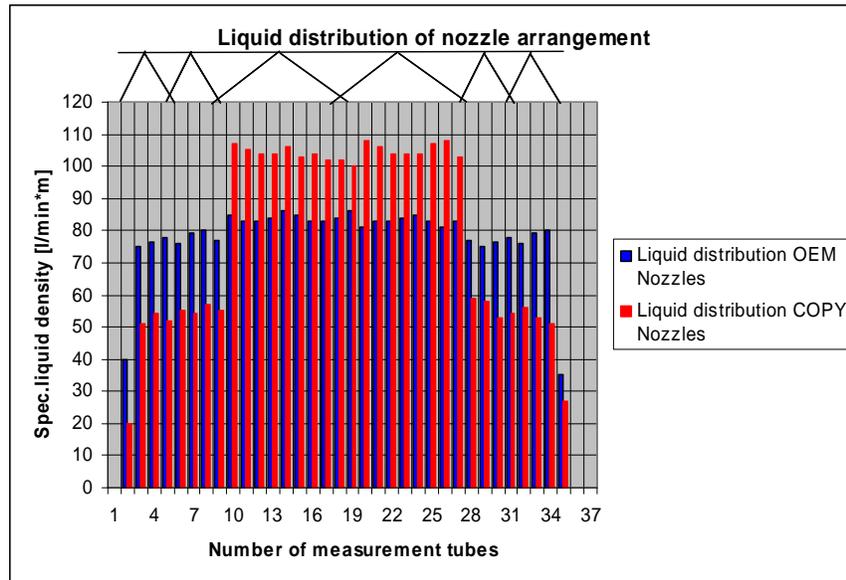


Fig. 13 – Variation in liquid distribution across the slab width.

The result of this type of cooling profile is shown on the surface temperature map in Fig. 14 where a pronounced “W-shape” final solidification profile is produced, this profile could lead to centre segregation problems even when soft reduction is applied.

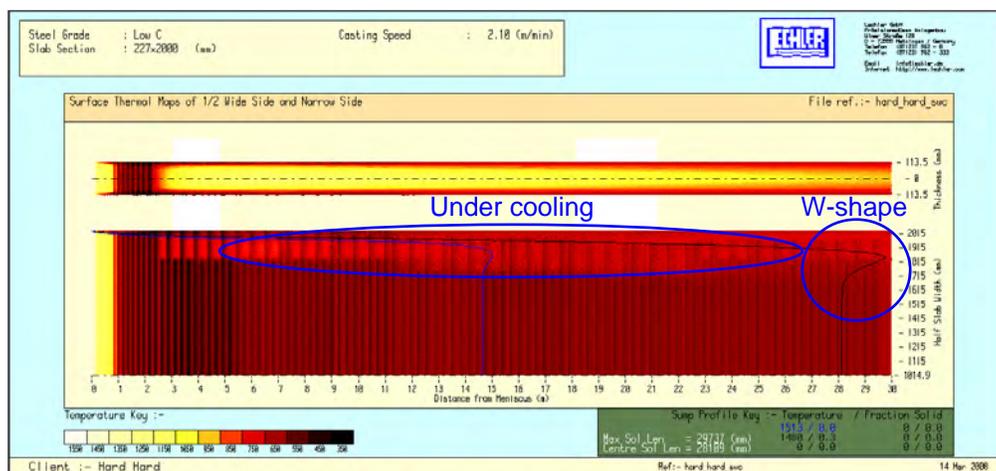


Fig. 14 – Slab surface temperature map.

In general the staggering of nozzles in alternate roll gaps is intended to provide even cooling along the total strand length. However, if staggering is not consequently and carefully applied, or totally ignored, uneven cooling across the slab width in alternate roll gaps will occur resulting in surface temperature differences. These differences can lead to distortions in the final solidification front giving the problematic final “W-shape” solidification profile.

To improve control the simple ON/OFF valves can be replaced by flow control valves, one for each strand width range (i.e. middle and wide). This enables the spray width control nozzle flows to be independently adjusted as the nozzles are turned on or off (Fig. 15) to achieve a more even surface temperature profile.

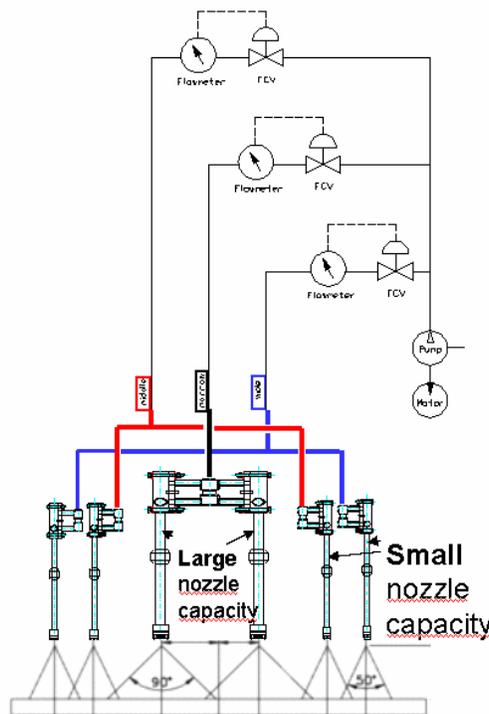


Fig. 15 – Sophisticated spray width control system.

### SPRAY WIDTH CONTROL SYSTEMS WITH VARIABLE SPRAY HEIGHT.

To overcome the problems associated with uneven cooling, automatic systems have been developed which can match the spray width to the slab width consistently throughout the width range.

These systems utilise two nozzles which are moved diagonally inline with the spray pattern to maintain the correct water distribution at the spray overlap positions as shown in Fig. 16. The advantages are that the nozzles can cool the optimum width on the slab surface, without over cooling the slab corners.

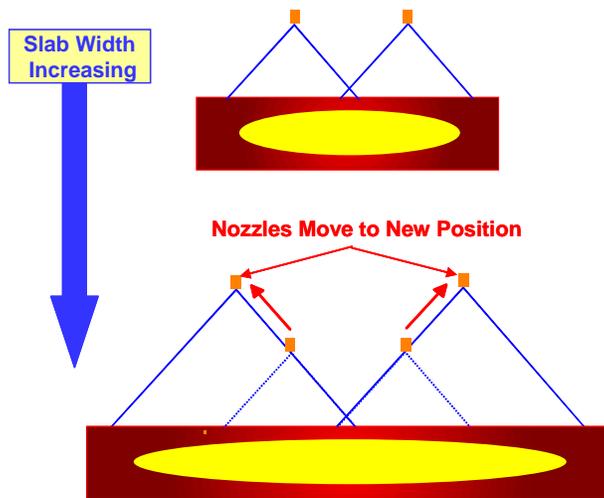


Fig. 16 – Spray width control with moving nozzles.

### **WATER FLOW CONTROL CONCEPT WITH VARIABLE SPRAY HEIGHT.**

The secondary cooling control for the moveable nozzle systems is much more complex than for the normal ON/OFF spray width control systems in that cooling zone water flows are dependant on both the casting speed and the nozzle positions.

The spray footprint on the slab surface is directly related to the nozzle position; to enable calculation of the correct water flows which will give the correct heat extraction, the nozzle position must be known at all times. The nozzle movement systems, which can be electro-mechanical or hydraulic are controlled by the cast slab width and feature position transducers to provide the nozzle position, failure of any of these items will result in incorrect slab cooling.

Also for this concept Lechler has developed a new nozzle type, again applying the MasterCooler SMART mounting principle for safe consistent positioning and rigid mounting (Fig 17). The stiffener plate supporting the extension pipe of the air mist nozzle prevents deflection of the pipe during actuator movement.

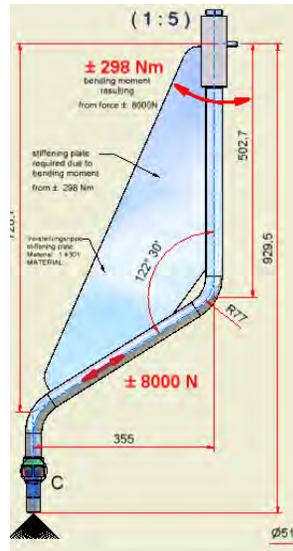


Fig. 17 – Moving nozzle design.

A spray width control system with variable spray height is an additional actuator in the already very sophisticated technology of modern slab casting. It adds to the complexity of segment design and machine control requirements. It also demands a very high degree of competence and discipline in maintenance in order to ensure consistent functionality in the harsh environment of continuous casting.

## CONCLUSION.

This paper once again illustrates the importance of a carefully designed secondary cooling system within the ever increasing complexities of modern slab casting. The machine configuration and consequently the cooling system concept are determined by both the product mix of steel grades to be produced and the expected machine production output. The paper also demonstrates that various technical solutions and concepts are being made available. Whether spray width control with a multi nozzle arrangement, or with a twin nozzle variable spray height control offers the better solution can not be answered with a yes or no and needs to be addressed to the various machine builders and the steel companies producing with both concepts. With a profound competence and the experience of more than 110 strands of modern slab casters equipped with the Lechler MasterCooler air mist nozzles, Lechler offers optimum nozzle solutions for all cooling concepts.

The previous example describing the differences of nozzle flow characteristics and their effect also highlights that, frequently small details are not recognised in the entire process and these can have disastrous consequences in connection with product quality and machine productivity.

Providing and maintaining adequate cooling water and compressed air quality, combined with top class maintenance procedures, is also essential in optimum caster performance.



Lechler GmbH  
Precision Nozzles • Nozzle Systems  
P.O. Box 13 23  
72544 Metzingen / Germany  
Phone: +49 (0) 71 23 962-0  
Fax: +49 (0) 71 23 962-333  
E-Mail: [info@lechler.de](mailto:info@lechler.de)  
Internet: [www.lechler.de](http://www.lechler.de)

## Maintenance Handbook for Air Mist Nozzles in Continuous Casting Machines

### Introduction

As with other manufacturing tools, proper maintenance of spray nozzles components cannot be ignored since there are many factors that will affect their level of performance over time. Experience tells us that nozzles require regular inspection and maintenance, and sometimes replacement, in order to preserve final product quality and to maintain production processes on a cost-efficient basis.

In the early stages of deteriorating performance, the overall effect may be hardly noticeable. It can be difficult to discover the source of the problem unless you know what to look for. In addition to causing the waste of electrical energy, water, chemicals, and other materials, poor spray nozzle performance can also directly affect the quality of the final product.

Nozzle performance can be compromised and even rendered totally ineffective by eroded, damaged, or obstructed nozzle orifices, the extent of which varies with the nozzle type, size and application.

Here are the basic problems which can occur when the nozzles used are not well-suited to the application, improperly installed or assembled and/or not properly maintained. But keep in mind that spray nozzles are not designed to last forever, which makes routine nozzles maintenance even more important.

### Erosion/wear

Gradual removal of metal from the nozzle orifice and internal flow passages which become larger and/or distorted. Flow is usually increased, pressure may be decreased, pattern becomes irregular, and the spray drops become larger.

### Corrosion

Breakdown of the nozzle material due to the chemical action of sprayed material or environment. Effect is similar to that caused by erosion and wear, with possible additional damage to the outside surfaces of the nozzle.

### Temperature

Certain liquids must be sprayed at elevated temperatures or in high temperature environments. This may have an adverse effect on nozzle materials not intended for high temperature applications. The nozzle may soften or break down.

### Caking

Build-up of material on the inside or outer edges of the orifice, caused by evaporation of the liquid. This leaves a layer of dried solids and obstructs the orifice or internal flow passages.

### Clogging

Unwanted solid particles blocking the inside of the orifice, restricting the flow and disturbing spray pattern uniformity.

LEADING SPRAY TECHNOLOGISTS



NOZZLES



LANCES



HEADERS



CONTROLS



SYSTEMS



Lechler GmbH  
Precision Nozzles • Nozzle Systems  
P.O. Box 13 23  
72544 Metzingen / Germany  
Phone: +49 (0) 71 23 962-0  
Fax: +49 (0) 71 23 962-333  
E-Mail: info@lechler.de  
Internet: www.lechler.de

## Maintenance Handbook for Air Mist Nozzles in Continuous Casting Machines

### Improper assembly

Some nozzles require careful re-assembly after cleaning so that internal components, such as gaskets, o-rings, and internal valves are properly aligned. Improper positioning may cause leakage as well as inefficient spray performance. Overtightening of nozzle caps onto bodies can cause thread stripping.

### Accidental damage

Damage to an orifice or nozzle by inadvertent scratching or by dropping during installation or operation. Also, smaller orifices can be severely damaged by use of improper tools during cleaning.

### Flow rate increase

In all nozzles, the flow rate will increase as the surfaces of the orifice and/or internal vane or core begin to deteriorate. With centrifugal, turbine or similar pumps, which provide variable flow rates at relatively constant pressures, the increased costs of wasted chemicals and water. Possible harm to the product or process quality can also result.

In applications using positive displacement pumps, which provide the same capacity regardless of pressure, the spraying pressure will decrease as the nozzle orifice enlarges because of wear or corrosion. This is effecting the turn down ratio of an air mist nozzle.

### Spray pattern quality

The pattern of flat fan sprays deteriorates by developing streaks and heavier flows in the center of the pattern, accompanied by a decrease in the effective spray angle coverage. Therefore, in application depending on uniformity of overlapping spray pattern such as coating, these non-uniform spray patterns can seriously affect the application results of the finished product quality.

### Cooling

Applications in which sprays are employed to cool solid objects include the cooling of continuously cast steel, fabricated products, processing equipment, tanks, etc.

Nozzle problems in spray cooling of continuously cast steel can cause product distortion and cracks. And in roll cooling, uneven spray patterns result in uneven wear of the roll surfaces, leading to costly roll regrinding. So, in addition to poor product quality, nozzle problems can cause excessive downtime.

### How to detect nozzle problems

#### Flow rate

With centrifugal pumps, nozzle flow rates usually increase at a given pressure when the orifice continues to wear. Since this increased flow will not be visually noticeable, periodic flow rate checks are suggested. These checks can be done by monitoring flow meter readings, or by collecting and measuring the spray from the nozzle for a given period of time at a specific pressure. These readings can then be compared to the flow rate listed in catalogue tabulations or compared to the flow readings from new, unused nozzles. When using positive displacement pumps, orifice wear is accompanied by a drop in the liquid li-

LEADING SPRAY TECHNOLOGISTS



NOZZLES



LANCES



HEADERS



CONTROLS



SYSTEMS



Lechler GmbH  
Precision Nozzles • Nozzle Systems  
P.O. Box 13 23  
72544 Metzingen / Germany  
Phone: +49 (0) 71 23 962-0  
Fax: +49 (0) 71 23 962-333  
E-Mail: [info@lechler.de](mailto:info@lechler.de)  
Internet: [www.lechler.de](http://www.lechler.de)

## Maintenance Handbook for Air Mist Nozzles in Continuous Casting Machines

ne pressure while the flow rate remains constant.

### Spray pattern

Visual inspection can easily reveal changes in the uniformity of flat spray patterns which are caused by orifice damage, clogging or caking; however, in cases where the orifice is wearing gradually, changes in spray pattern may not be detected until after the flow has increased substantially. In applications requiring accurate uniformity of spray coverage, special equipment or tests are required to check pattern uniformity.

### Nozzle alignment

When using several flat spray nozzles on a manifold to provide an overall uniform coverage on a strand passing under the sprays, it is very important that all nozzles be oriented correctly in relation to each other. That is, all the flat spray patterns should be aligned to ensure accurate coverage. All patterns should also be parallel to each other.

### Consider alternatives in your present spray system

Reduce the quantity of abrasive particles or concentration of corrosive chemicals. While these changes cannot be made in most applications, possible reductions in the amount of abrasive particles in the feed liquid, and changes in the size and shapes of the particles may reduce the wear effects. If corrosion is a problem, the corrosive activity of a solution can occasionally be reduced by using different concentrations and/or temperatures, depending on the specific chemicals involved.

In many applications, orifice deterioration and clogging is caused by a solid dirt particles in the sprayed liquid. In spraying systems involving continuous spray water recirculation, it's possible for water to be contaminated with dirt and debris which can cause orifice clogging and/or orifice wear. To minimize this type of nozzle problem, line strainers or nozzles with built-in strainers are recommended with a screen mesh size chosen to trap larger particles that may clog the nozzle orifice or vane.

### Prevent damage to the orifice during the cleaning process

As part of a standard nozzle maintenance and inspection procedure, nozzle orifices should be cleaned regularly and carefully, using cleaning probes made of materials much softer than the nozzle orifice surface. Otherwise, the critical orifice shape or size can be permanently damaged, thereby resulting in distorted spray patterns and/or increased capacity.

Specifically, bristle brushes or wooden and plastic probes can be used, while wire brushes, pocket knives or welders' tip cleaning rasps are to be avoided. In some stubborn clogging problems, it is advisable to soak the clogged orifice in a non-corrosive cleaning chemical to soften or dissolve the clogging substance.

### Spray Nozzle Maintenance Workshop

We'll personally conduct a workshop on spray nozzle maintenance for you and your staff. Included in the workshop is a wealth of information on spray nozzle performance problems, causes and solutions. We also address the costs associated with spray nozzles that aren't performing properly.

LEADING SPRAY TECHNOLOGISTS



NOZZLES



LANCES



HEADERS



CONTROLS



SYSTEMS



Lechler GmbH  
Precision Nozzles • Nozzle Systems  
P.O. Box 13 23  
72544 Metzingen / Germany  
Phone: +49 (0) 71 23 962-0  
Fax: +49 (0) 71 23 962-333  
E-Mail: info@lechler.de  
Internet: www.lechler.de

## Maintenance Handbook for Air Mist Nozzles in Continuous Casting Machines

### Air Mist Nozzles of Secondary Cooling Systems in Continuous Casting Machines

Continuous casting machines are now required to cast a wide range of steel grades while maximising production output. Consistent production of prime quality product requires increased operational and maintenance flexibility of the caster so that the optimum casting parameters can be maintained for each steel grade. This flexibility extends not only to the machine elements and control systems, but also to the secondary cooling system and demands more efficient and reliable spray cooling. Attentive design of secondary cooling systems, through cooling zone positioning, nozzle layout, nozzle selection and the use of appropriate secondary cooling control systems can provide these requirements. Minimum down time for maintenance is a key factor in maximising caster production; the use of the latest piping header systems and nozzle mounting arrangements can contribute to minimum secondary cooling maintenance. These header systems provide a rigid and self-aligning mounting for the nozzle, ensuring both nozzle alignment and maintenance accessibility.

Nozzle characteristics must be investigated and test procedures developed to measure cooling patterns and heat transfer. Improved nozzle design and air/water systems gives in better water distribution and this reduces surface defects, corner cracking and core segregation. There are also important operational benefits which enable expansion in the product mix and production capacity.

#### Of particular concern are:

- Nozzle type selection according to the product mix and machine design
- Heat transfer coefficients measurements of the spray nozzles
- Air-water ratio
- Water turn-down ratio
- Water distribution
- New methods of nozzle mounting and new header pipe designs
- New air mist nozzles for long product casting

#### Nozzle selection according to machine design and product mix

Unlike in the early days the layout of the secondary spray cooling system is one of the first steps when a new continuous casting machine is designed or when an existing machine undergoes a major revamping. However, the determination of the strand surface and internal temperature distribution along the metallurgical length of the machine comes first. This is followed by the application of a thermo-mathematical computer model for the calculation of the heat transfer coefficient (HTC) distribution for each steel grade and product dimension. The spray nozzle sizes (flow rates) for every cooling zone are established in the next step. The use of mathematical models which are based on actual HTC measurements of spray nozzles help to determine the exact nozzle specification including details such as min. and max. water flows, nozzle pitches, spray heights and nozzle overlaps. An understanding of the cause of strand defects also influences the specification of the spray nozzle parameters.

Only in a second phase the mechanical design of the machine segments can follow. This practise underlines the significant effect which the spray nozzle arrangement in general and the nozzle design in particular have on the quality of the continuously cast products.

A defect free slab, bloom, billet or beam blank and an economical operation are the objectives to be achieved by the spray nozzle cooling system. The nozzle manufacturer must have detailed knowledge of the behavior of the nozzles under operation conditions and the machine segment design.

#### LEADING SPRAY TECHNOLOGISTS



NOZZLES



LANCES



HEADERS



CONTROLS



SYSTEMS



Lechler GmbH  
Precision Nozzles • Nozzle Systems  
P.O. Box 13 23  
72544 Metzingen / Germany  
Phone: +49 (0) 71 23 962-0  
Fax: +49 (0) 71 23 962-333  
E-Mail: [info@lechler.de](mailto:info@lechler.de)  
Internet: [www.lechler.de](http://www.lechler.de)

## Maintenance Handbook for Air Mist Nozzles in Continuous Casting Machines

### Air-Water ratio

A higher water flow is not the only factor decisive for the heat transfer coefficient as mentioned above. The nozzle spray angle and spray height are playing an important role, too. Both determine the spray foot print (width and depth of spray) and are therefore, factors of the water jet density (water flux) and the jet impact. Besides these two variables the ratio between the compressed air volume and the water flow must be considered as another important factor in the secondary cooling process. Spray cooling on the strand involves boiling and the formation of a steam layer on top of the steel surface. The compressed air is providing the kinetic energy necessary for penetration of the droplets through this steam layer.

### Water turn down ratio

Variations in casting speeds as a result of normal operation practises such as start-up, capping off, ladle or tundish changes and because of the product mix (different steel grades and strand dimensions cast) require a certain turn down ratio of the spray nozzles. Another term for the nozzle turn down ratio is control ratio (maximum water flow divided by the minimum water flow). It means the range between the minimum and maximum water flow rate over a defined water pressure range of a given spray nozzle. It is also important to state the air pressure(s) and if the air pressure is constant or variable. It is desired to have air mist nozzles with a wide turn down ratio in order to keep the nozzle varieties in one particular machine at a minimum.

Both maintenance and inventory managers appreciate this effort. Nevertheless, in modern casters it is essential to have a certain number of nozzle varieties in order to fulfil the requirements with regard to the product quality over a wide range of steel grades. This goes especially if spray width control (margin control) is needed to control corner temperatures.

### Water distribution

Once the secondary cooling system layout is completed and the mechanical design of the segments is known, it is the spray nozzle manufactures task to design nozzles providing an uniform water distribution across the strand surface and over the entire turn down ratio. Tolerances of +/- 30% from the mean value can be achieved with a multi nozzle arrangement at water pressures between 1,0 and 7,0 bars.

### New methods of Nozzle Mounting and Header Pipe Designs

Because of their internal mixture, air mist nozzles require two separate feed pipes for compressed air and water. Until recently small diameter hydraulic pipes were used to feed the fluids and to hold the nozzles in place. Only in special cases, where one fluid was fed directly by a hose, additional supports were provided.

The conventional air mist nozzles mounted on these small pipes are hidden inside the segment frame work as shown in Figure 1.

LEADING SPRAY TECHNOLOGISTS



NOZZLES



LANCES



HEADERS



CONTROLS



SYSTEMS



Lechler GmbH  
Precision Nozzles • Nozzle Systems  
P.O. Box 13 23  
72544 Metzingen / Germany  
Phone: +49 (0) 71 23 962-0  
Fax: +49 (0) 71 23 962-333  
E-Mail: info@lechler.de  
Internet: www.lechler.de

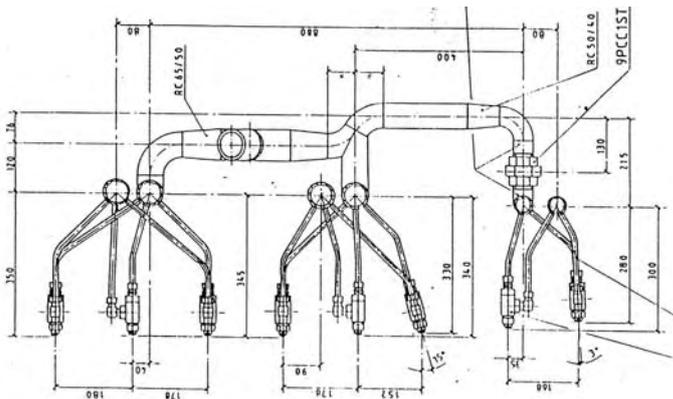
## Maintenance Handbook for Air Mist Nozzles in Continuous Casting Machines



**Fig. 1: Air mist nozzles fed and installed by means of small and long hydraulic pipes**

Having the nozzles mounted so close to the strand makes maintenance (cleaning or adjustment) impossible unless the segment is removed from the machine. Moreover, in case of a break out nozzles must be replaced completely which is very costly.

Strand surface defects can often be traced back to misaligned spray nozzles. Header pipes such as shown in Figure 2 are one source of such misalignments. The many small air and water pipes are often out of position due to mechanical impact or thermal reasons. The large number of small individually bent pipes are also expensive to manufacture.



**Fig. 2: Header pipe with many small, individually bent fluid feed pipes**

Within the last 2 years the vertical segment piping with square air and water main header pipes almost became an industry standard design. The air mist nozzles now equipped with plates are bolted vertically onto adaptor plates, Figure 3.

LEADING SPRAY TECHNOLOGISTS



NOZZLES



LANCES



HEADERS



CONTROLS

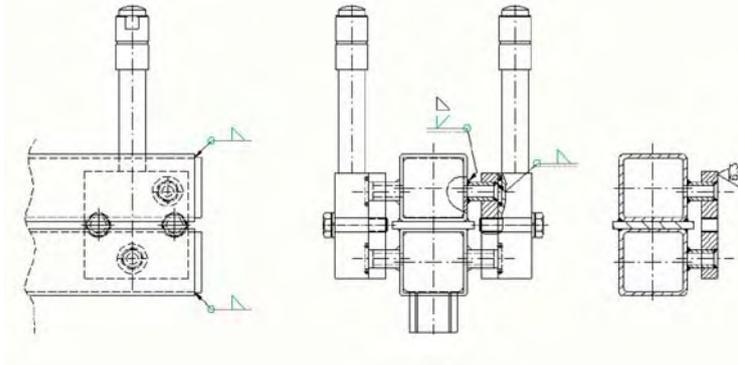


SYSTEMS



Lechler GmbH  
Precision Nozzles • Nozzle Systems  
P.O. Box 13 23  
72544 Metzingen / Germany  
Phone: +49 (0) 71 23 962-0  
Fax: +49 (0) 71 23 962-333  
E-Mail: info@lechler.de  
Internet: www.lechler.de

## Maintenance Handbook for Air Mist Nozzles in Continuous Casting Machines



**Fig. 3: Air mist nozzle with vertical plate connection and square pipe header manifold**

Small diameter fluid feed pipes are no longer necessary. All nozzles are mounted outside of the framework at the rear side of the segment with only the nozzle pipe, carrying the spray tip, reaching down to the spray position. A very rigid header pipe and a nozzle self alignment is the result. The nozzle spray position is always secured. A "Hoseless" fluid supply system becomes also possible.

In order to maintain an identical nozzle length in one segment, the nozzles are bolted onto adaptor plates of a tailored length to compensate for the in built bending radius, Figure 4.



**Fig. 4: Air mist nozzle with vertical plate connection and adaptor plate (SGA1, Salzgitter/Germany)**

Nozzle staggering between the roller gaps within one segment becomes much easier since different nozzle positions can be served from only one header pipe manifold. Nozzle staggering is one method to equalize the water distribution along the strand in length direction with the intention to eliminate surface defects and cracks. Figure 16 shows such a design with the left and middle nozzles installed in the same plane (roller gap) and the right nozzle in the plane above and below.

LEADING SPRAY TECHNOLOGISTS



NOZZLES



LANCES



HEADERS



CONTROLS

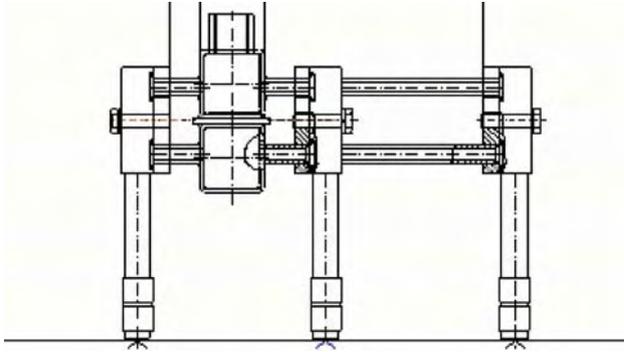


SYSTEMS



Lechler GmbH  
Precision Nozzles • Nozzle Systems  
P.O. Box 13 23  
72544 Metzingen / Germany  
Phone: +49 (0) 71 23 962-0  
Fax: +49 (0) 71 23 962-333  
E-Mail: info@lechler.de  
Internet: www.lechler.de

## Maintenance Handbook for Air Mist Nozzles in Continuous Casting Machines



**Fig. 5: Nozzle stagering**

### Nozzle and tip alignment

It is of paramount importance that spray nozzles are correctly aligned and adjusted in within the segment on the piping system/headers.

Misaligned and off position air mist nozzles can often be seen, the sprays are colliding with support roll so reducing their cooling efficiency.



**Fig. 6: Misaligned and off position air mist nozzles**

Lechler nozzle tips are equipped with a standard 2-key fixing which ensures the correct position of the spray tip and hence the correct spray direction and plane. However, there are cases where the tip adapter on the extension pipe of the nozzle has four holes so that the nozzle tip can be turned by 90° for versatility reasons. In such a case the correct nozzle tip spray direction has to be checked and ensured during assembly of the nozzles and headers.



**Fig. 7: Mastercooler Nozzle tip with 2 alignment keys**

LEADING SPRAY TECHNOLOGISTS



NOZZLES



LANCES



HEADERS



CONTROLS

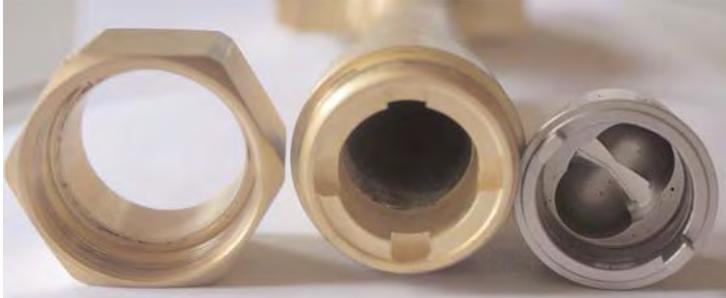


SYSTEMS



Lechler GmbH  
Precision Nozzles • Nozzle Systems  
P.O. Box 13 23  
72544 Metzingen / Germany  
Phone: +49 (0) 71 23 962-0  
Fax: +49 (0) 71 23 962-333  
E-Mail: info@lechler.de  
Internet: www.lechler.de

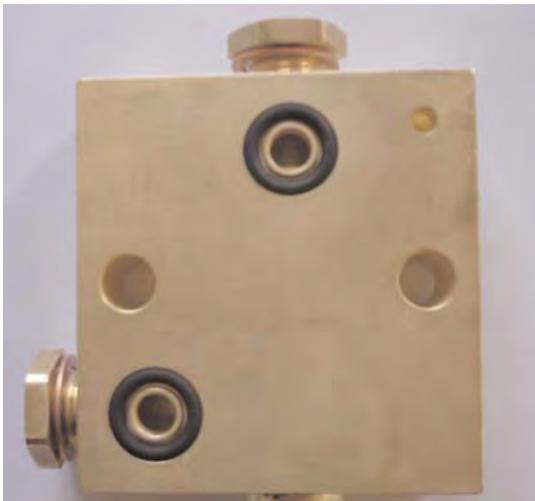
## Maintenance Handbook for Air Mist Nozzles in Continuous Casting Machines



**Fig. 8: Mastercooler tip with 2 keys, pipe adapter with 4 key holes and nut**

### Nozzle Body Interface

It is important that the nozzle body mounting surface is kept clean and free of marks in order to secure a tight connection. Please make sure that new o-rings are being used whenever the nozzle is removed for a major repair or maintenance off site. It is also important that the plugs come tight on with undamaged copper seals.



**Fig. 9: Mastercooler nozzle body mounting surface with air and water inlet holes including o-rings, air and water plugs including copper seals.**

### Air and water filtration

Lechler recommends to maintain the following air and water quality by means of applying the appropriate utilities.

LEADING SPRAY TECHNOLOGISTS



NOZZLES



LANCES



HEADERS



CONTROLS



SYSTEMS



Lechler GmbH  
Precision Nozzles • Nozzle Systems  
P.O. Box 13 23  
72544 Metzingen / Germany  
Phone: +49 (0) 71 23 962-0  
Fax: +49 (0) 71 23 962-333  
E-Mail: info@lechler.de  
Internet: www.lechler.de

## Maintenance Handbook for Air Mist Nozzles in Continuous Casting Machines

### Air Mist Cooling Air Supply

- Dewpoint 3°C
- Cleanliness 99.9% removal of 5 micron particles  
99.5% removal of 1 micron particles  
Oil free.

The air pressure shall be controlled at 2 bars constant.

### Spray Cooling Water Quality

The water presented to the machine is required to be equal to or better than the following conditions:

- Suspended Solids 20 ppm
- Particle Size 0.2 mm
- Total Salt Content 3000 ppm
- Sulphate (SO<sub>4</sub>) 500 ppm
- Chloride (Cl) 250 ppm
- Silica (as SiO<sub>2</sub>) 150 ppm
- Carbonate Hardness (CaCO<sub>3</sub>) 300 ppm
- Total Hardness (CaCO<sub>3</sub>) 1000 ppm
- pH 6 to 9.5
- Free Oil 5 ppm
- Dissolved Oil 10 ppm

LEADING SPRAY TECHNOLOGISTS



NOZZLES



LANCES



HEADERS



CONTROLS



SYSTEMS



Lechler GmbH  
Precision Nozzles · Nozzle Systems  
P.O. Box 13 23  
72544 Metzingen / Germany  
Phone +49 (0) 71 23 - 962 - 0  
Fax +49 (0) 71 23 - 962 - 333

E-Mail: [info@lechler.de](mailto:info@lechler.de)  
Internet: [www.lechler.de](http://www.lechler.de)



**Belgium:** Lechler S.A./N.V. · Avenue Mercatorlaan, 6 · 1300 Wavre · Phone: (10) 225022 · Fax: (10) 243901 · [info@lechler.be](mailto:info@lechler.be)  
**China:** Lechler Intl. Trad. Co. Ltd. · Beijing · Rm. 418 Landmark Tower · No. 8 Dong San Huan Bei Lu · Phone: (86) 1084537968, Fax: (86) 1084537458 · [info@lechler.com.cn](mailto:info@lechler.com.cn)  
**Finland:** Lechler Oy · Posiinitehtaankatu 7 · 04360 Kerava · Phone: (358) 207856880 · Fax: (358) 207856881 · [info@lechler.fi](mailto:info@lechler.fi)  
**France:** Lechler France, S.A. · Bât. CAP2 B51 · 66-72, Rue Marceau · 93558 Montreuil cedex · Phone: (1) 49882600 · Fax: (1) 49882609 · [info@lechler.fr](mailto:info@lechler.fr)  
**Great Britain:** Lechler Ltd. · 1 Fell Street, Newhall · Sheffield, S9 2TP · Phone: (0114) 2492020 · Fax: (0114) 2493600 · [info@lechler.com](mailto:info@lechler.com)  
**India:** Lechler (India) Pvt. Ltd. · Plot B-2 · Main Road · Wagle Industrial Estate · Thane (W) · 400604 · Phone: (22) 40634444 · Fax: (22) 40634497 · [lechler@lechlerindia.com](mailto:lechler@lechlerindia.com)  
**Sweden:** Lechler AB · Spärrgatan 8 · SE-653 41 Karlstad · Phone: (46) 54 13 70 30 · Fax: (46) 54 13 70 31 · [info@lechler.se](mailto:info@lechler.se)  
**Spain:** Lechler S.A. · Avda. Pirineos 7 · Oficina B7, Edificio Inbisa I · 28700 San Sebastián de los Reyes, Madrid · Phone: (34) 916586346 · Fax: (34) 916586347 · [info@lechler.es](mailto:info@lechler.es)  
**USA:** Lechler Inc. · 445 Kautz Road · St. Charles, IL 60174 · Phone: (630) 3776611 · Fax: (630) 3776657 · [info@lechlerUSA.com](mailto:info@lechlerUSA.com)