LAMINAÇÃO - 2011
48º SEMINÁRIO DE LAMINAÇÃO
PROCESSOS E PRODUTOS LAMINADOS E REVESTIDOS
24 a 27 de outubro de 2011 — Santos - SP
ISSN 1983-4764

CVC CHECK VALVE FOR DESCALING NOZZLE AS A TOOL TO PROTECT INGOTS AGAINST UNWANTED COOLING EFFECTS IN HOT STRIP MILLS[1]

Folker Borchardt[2]
Georg Lohse[3]
Jochen Paal[4]

Abstract

Steel industry is faced by demands for diversification and higher quality steel grades, shorter delivery times and fluctuation of production scales. Application of descaling technology in steel milling process is a very special field of engineering. Production changes due to market influences will create the necessity of technological optimization. A well known problem for the rolling process is spilling water out of turned off upper descaling headers. Uncontrolled water on the surface leads to inhomogeneous temperature gradients of the ingot material and causes unwelcome material properties and defects for the finished product. Spraying System CVC (check valve control) design contains as central part a spring preloaded check valve, which closes automatically, when the high pressure descaling process has finished.

Key words: Descaling nozzles; Anti water hammering measures; Surface cooling; Heat transfer

1 *Technical contribution to the 48th Rolling Seminar – Processes, Rolled and Coated Products, October, 24th-27th, 2011, Santos, SP, Brazil.*
2 *Dr. Ing.- habil. – Spraying Systems GmbH*
3 *Dr. Ing. – Spraying Systems GmbH*
4 *Spraying Systems GmbH*

ISSN 1983-4764

1 INTRODUCTION

Steel industry is faced by demands for diversification and higher quality steel grades, shorter delivery times and fluctuation of production scales. Practical answers are continuous improvement of processes, cost reduction activities, stabilization of manufacturing processes and introduction of total quality management systems.
Application of descaling technology in steel milling process is a very special field of engineering.
Spraying System is a specialised nozzle and system supplier and is long standing established in the market. We take care by state of the art research and design to meet customers' needs like:

- High performance
  - High Impact
  - Consistent spray
  - Optimized water consumption
- Long lifetime/ low life cycle cost
- Robust design
- Low sensitivity to production implications
- Easy maintenance
  - Principle of confounding avoidance
  - Low positioning tolerance/ self alignment
- High availability for spare part supply
- Constant performance and quality in different scales, tested internally

Nozzle selection and arrangement is fixed by OEM of hot strip mills normally. They select nozzle type, water flow, nozzle pitching, spray distance, overlap and general arrangement. Descaling regime and system is designed according request of customer's production, e.g. steel brand, product dimensions, rolling speed, variation of dimensions and pass sequence.
Production changes due to market influences (like deviating of material properties) will create the necessity of technological optimization. A well known problem for the rolling process is spilling water out of turned off upper descaling headers, which drains uncontrolled on the surface of the ingots. Uncontrolled water on the surface leads to inhomogeneous temperature gradients of the ingot material and causes unwelcome material properties and defects for the finished product.
Standard priming systems are designed in that way, that a continuous filling water pressure exists inside the descaling headers and all descaling nozzles. It is the best precaution for avoiding formidable water hammering. Water hammering occurs when the nozzles, headers and piping is drained due to gravity. High pressurized water will come by high velocity and compress the air inside the piping. In extreme situations damages might happen on system elements.
In connection with the analysis of existing equipment and conditions Spraying Systems Deutschland GmbH will generate solutions for process stabilization, energy savings and quality improvements.

ISSN 1983-4764

2 PRIMING

2.1 Standard or Conventional Systems

When air enters a water piping system due to any technical reason (leakages, lower pressurising compared to normal barometric pressure, air injection into piping, etc.) it will creates air bubbles or deposits in areas of higher altitude.
When this piping system is pressurised by any technical regime, all air inside the system will be compressed. It may create damages on sealing's, piping or other parts of the system, when expanding. It creates noise, vibration and a delay or an unstable flow of the water.
Pre-filling systems (using booster pressure of 0,2...approx. 0,5 MPa, 35°C) are implemented in descaling plants normally, to get a stable, continuous pressure in the complete high pressure systems in the unload mode, when no high pressured water for descaling purpose is required. Either the system is filled by a by-pass valve located behind the last stop valve (descaling water on/off valve) with plant water, or suction control lifting valves(state of the art plunger pumps) allow the suction water to pass to pump head and to fill up the complete high pressure system after the pumps including the upper nozzle headers.
Descaling systems are - so called- open water hydraulic systems, because the pressurized water passes nozzles and will be recycled in a waste water treatment plant. Depending on orifice of used nozzle tips, number of nozzles and booster/ priming pressures a certain amount of water splashes continuously out of the nozzles tips. Resulting amount of water can get several litres per nozzle and second easily. This water splashes on the ingots and creates stripes of water on the surface. Especially in Steckel mill application, when the material is rolled several times in a reversal motion, these water stripes will be superpositioned all times when the ingot passes the descaling header. A CFD cooling simulation (Figures 1 – 5) gives an insight how steadily impinging splash water affects the temperature distribution at the surface as well as inside the material core. The resulting temperature drop may indicate alteration of the material properties like hardness and ductility leading to unfavourable deformation behaviour.

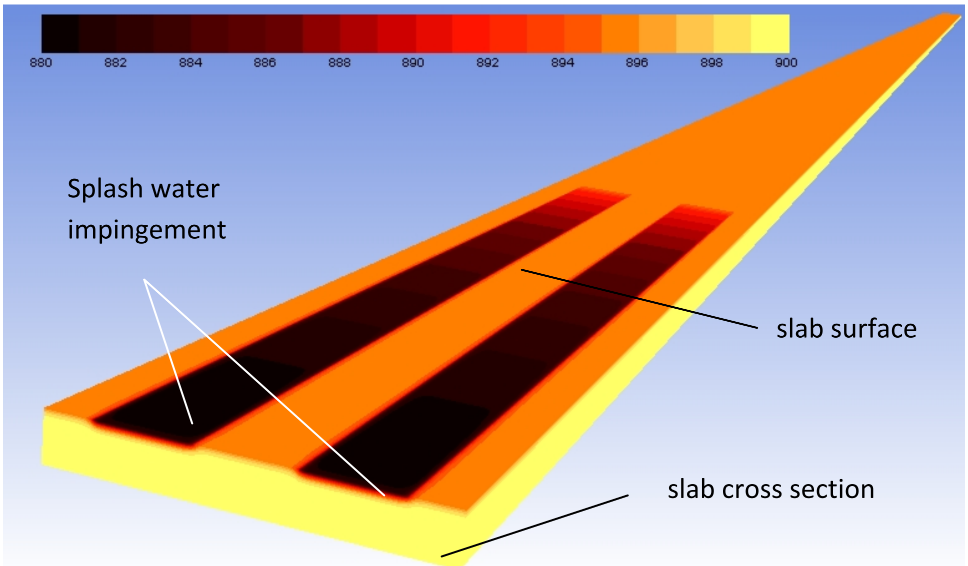

Figure 1: Temperature profile on slab surface and cross section after 1 second of water splash impinging on the slab surface; slab thickness is 16 mm.

ISSN 1983-4764

Figure 1 shows the temperature distribution after 1 second of water splash impinging on the slab surface. The initial slab temperature is supposed to be 900°C. The maximum temperature drop is calculated to ca. 20 °C.

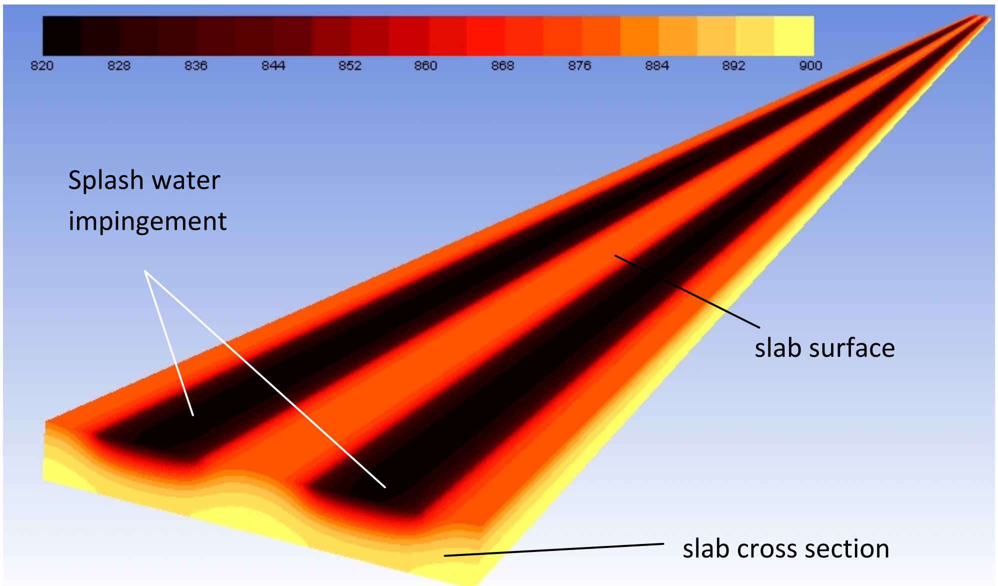

Figure 2: Temperature profile on slab surface and cross section after milling pass and steady water splash impinging on the slab surface; slab thickness is 16 mm.

Figure 2 shows the temperature evolution when the milling pass has finished and the header behind the rollers was splashing water continuously (cooling interaction time is 6.6 seconds).
Both simulations contain a section view of 2 parallel nozzles only using symmetric boundary conditions at slab cross section. Water film width created by steady water impingement on slab surface is supposed to be 30 mm and nozzle to nozzle distance is 200 mm. Pitching is 60 mm, rolling speed is 1,5 m/ sec and vertical distance is 200 mm. Cooling is done by stable film boiling, forcing convection as well as radiation. The computed temperature profile predicts a locally maximum temperature drop of up to 80 °C after finishing of milling pass.
Figure 3, 4 and 5 show a similar example with a slab of 8 mm thickness, an initial temperature of 850 °C and a rolling speed of 2,0 m/s.
Cooling interaction is calculated for a cooling time of 5,0 sec for complete milling pass. Supposed geometric data's are similar to a.m. calculation.
The temperature drop depending on cooling time on surface and inside the steel is shown in diagram of Figure 4. The diagram shows the temperature for the center position of the splash water, thereby the different curves are describing the temperature at various distances from the slab surface inside the bulk material. A comparison of the curves reveals that maximum temperature drop occurs at the slab surface. For higher distance to the slab surface this effect decreases and can be traced back to heat conduction of the inner heat of the bulk material.

ISSN 1983-4764

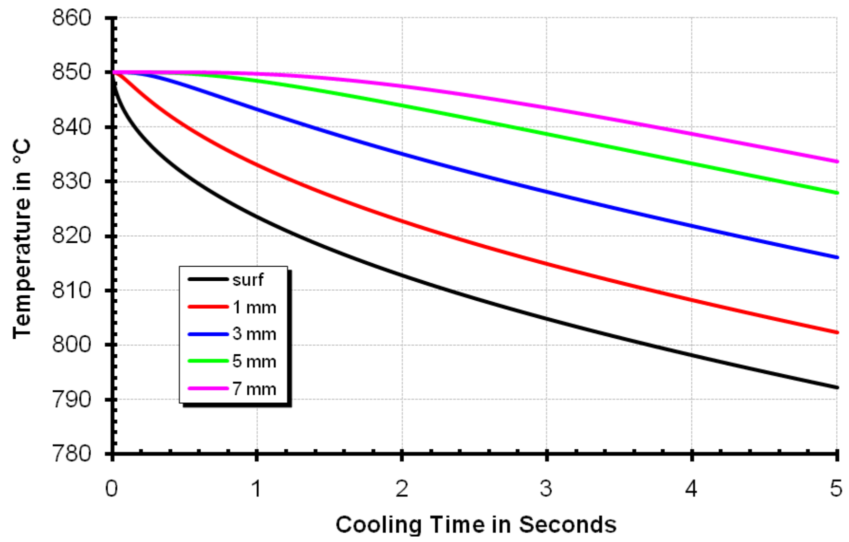

Figure 3: Temperature profiles depending on cooling time inside the material.

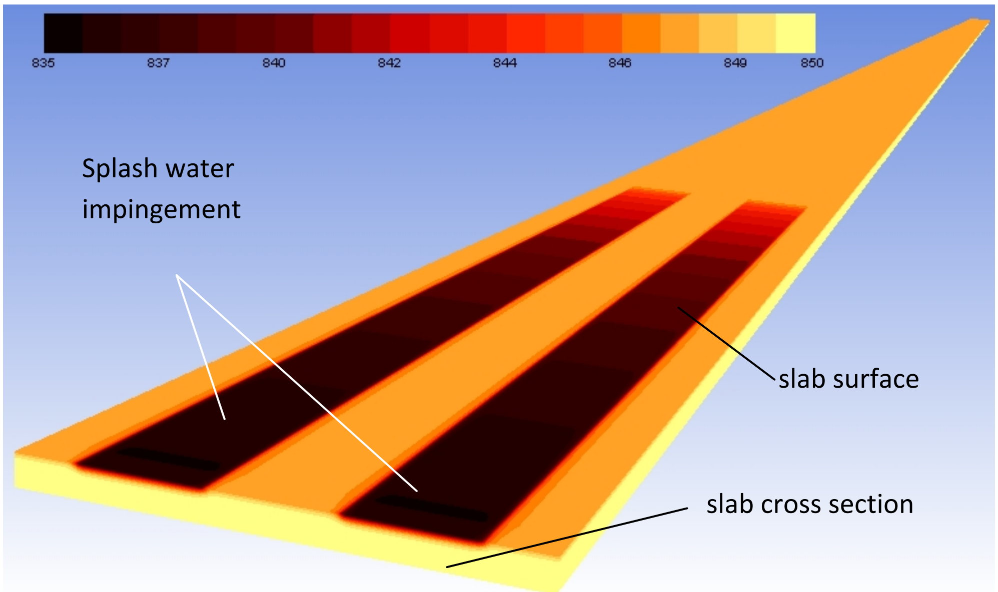

Figure 4: Temperature profile on slab surface and cross section after 1 second of water splash impinging on the slab surface; slab thickness is 8 mm.

Figure 4 shows the temperature drop after 1 second. The simulation of Figure 3 predicts a maximum temperature drop on the slab surface of ca. 25 °C

ISSN 1983-4764

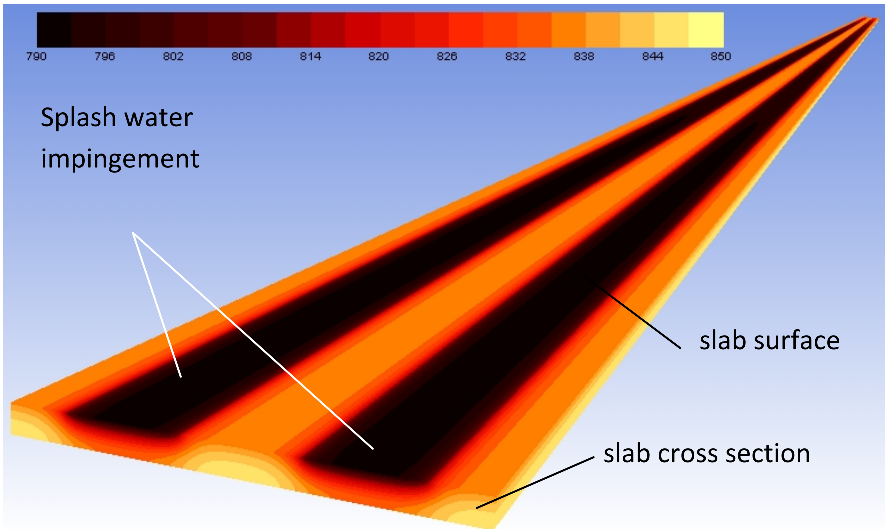

Figure 5: Temperature profile on slab surface and cross section after milling pass and steady water splash impinging on the slab surface; slab thickness is 8 mm.

For the slab surface a maximum temperature drop is calculated to round 60 °C for the rolling cycle as shown in Figure 5 for a cooling interval of 5 sec. From Figure 3 can also be taken that the temperature drop at distance to slab surface of 5 mm already exceeds 20°C. Such a local temperature drop can lead under certain circumstances local phase transformation or micro phase transformation. This causes on a macro scale inhomogeneous material properties like hardness and ductility leading to undesirable deformation behaviour.
The thinner the material the stronger the cooling effects the material core. Considering constant a slab width and similar initial temperature, it can be stated that the lower the slab thickness, the lower material flux and therefore the lower heat flow volume is which results in a stronger cooling effect in general. Due to larger general surface area with respect to material volume a quicker cooling is evident. Cooling speed in general is increased by splash water additionally.
Uncontrolled rapid cooling is unacceptable for sensitive or special alloys often. How to avoid water hammering and unwelcome slab cooling simultaneously?

2.2 CVC Valve Design (Check Valve Control)

By request of some of our hot strip mill clients Spraying System organisation started to develop devices avoiding cooling by heavy splash water. Development core was a design, matching to already existing nozzle tips in the market with no design changes, high flow rates and long lasting arrangements to expand maintenance periods to a maximum. CVC inserts should be useful up to 25 MPa (HiScale nozzles) or 40 MPa (MiniHiScale nozzles and DescalePro).

ISSN 1983-4764

Figure 5: CVC valve design.

Spraying System CVC (check valve control) design contains as central part a spring preloaded check valve (seat and poppet), which closes automatically, when the high pressure descaling process has finished. Priming or other system water will be stopped and the heavy splash out and therefore unwelcome surface cooling is stopped.
The inserts are designed for a minimum of pressure drop or in other words for a maximised flow capacity. For HiScale nozzle tip applications CVC can be used up to installation size ..50 (approx.177 lpm @ 25 MPa) and for MiniHiScale up to size..40 (approx.180 lpm @ 40 MPa). A vane after the spring will reduce turbulences certainly to get a maximum of descaling process efficiency. An integrated damping system in connection with a good guidance system protects valve seat and cone for mechanical damages by resonances. CVC enclosure is manufactured as a cartridge.
Complete arrangement is made for high temperature acceptance which will happens, when a slab is parking under the header and no additional water cools down the descaling nozzle and inserts. Tip materials are designed for high heat fluctuation resistance.
Particles in the descaling water up to 150 micron size have no significant impact to lifetime of wear parts. Lifetime of CVC equipment is multiple times longer than the nozzle tips itself. CVC was designed for different nozzle design and all flow applications.
Due to complete design, slightly longer welding nipples in combination with new height adjustment of upper nozzle header are required for proper operation at site.

3 SUBSUMPTION

Integration of CVC valves into existing descaling systems (upper nozzle headers) or for new designed plants is a successful measure to avoid unwelcome additional cooling on slabs.
Considering a constant a slab width and slowly lowering heat storage amount by natural convection and radiation, it can be additionally stated that the lower the slab thickness, the lower material flux and therefore the lower heat flow volume is which

ISSN 1983-4764

results in a stronger cooling effect in general. Due to larger general surface area with respect to material volume a quicker cooling is evident. Unwelcome cooling effect in general is increased by splash water additionally. The more often slabs are passing headers with priming for anti water hammer measures the stronger the cooling effects to the surface and material core due to overlay of the cooling traces.
A common change of nozzle tips and CVC cartridges is an approved step for modernization of existing header systems. In case of male functions of accumulator systems (compressed air enters high pressure piping) special subassemblies might be used to realize a controlled air vent by means of bypass solutions.
By CVC application unwelcome surface cooling due to massive heat convection is impossible. The material behaviour will match much better for milling process or quality improvements which are essential for automotive or special applications. Developments for higher priming pressures up to 1,5 MPa are pending.

BIBLIOGRAPHY

1 F. Vollertsen, S. Vogler: Werkstoffeigenschaften und Mikrostruktur, Carl Hanser Verlag, München, 1989
2 N.J. Petch: the Cleavage Strengt hof Polycrystals, Journal of Iron and Steel Institude, 174(1951), page 25-6
3 Schwertfeger,K; Metallurgie des Stranggießen; Verlag Stahl und Eisen, Goslar 1991, page 116