Maintenance Handbook for Air Mist Nozzles in Continuous Casting Machines
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Introduction

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

The overall effect may be hardly perceivable in the early stages of worsen performance. It can be difficult to discover the reason of the problem normally unless you know what to look for. Poor spray nozzle performance can also directly influence the quality of the final product. In addition it causes waste of electrical energy, water, chemicals, and other materials.

Nozzle performance can be negatively affected and even transformed into totally ineffective by eroded, damaged, or obstructed nozzle orifices. The extent of nozzle performance reduction varies with the nozzle type, size and application.

Following a short description of basic problems which can occur when implemented nozzles are not well-suited to the application, improperly installed or assembled and/or not properly maintained. Please keep in mind that spray nozzles are not designed to last for eternity. It makes routine nozzles maintenance even much more important.
Accidental damage

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

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 particle blocking the inside of the orifice, restricting the flow and disturbing spray pattern uniformity.

Corrosion

Breakdown of the nozzle material happens 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.

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.

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.

Flow rate increase

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

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

Improper assembly

Some nozzles require a very accurate re-assembly after cleaning so internal components, such as gaskets, o-rings, and internal valves are properly aligned. Improper positioning may cause leakages as well as in-efficient spray performance. Over tightening of nozzle caps onto bodies can cause thread seizing.

Spray pattern quality

This pattern of flat fan sprays deteriorates by developing streaks and heavier flows in the centre 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.

Temperature

Certain liquids must be sprayed at raised temperatures or in high temperature environments. This may have a harmful effect on nozzle material not intended for high temperature applications. The nozzle material may soften or break down.
How to detect nozzle problems

Flow rate

Nozzle flow rates usually increase at a given pressure when the orifice continues to wear when using centrifugal pumps. Periodic flow rate checks are suggested since this increased flow will not be visually noticeable. 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 have to be compared to the flow rate listed in catalogue tabulations or compared to the flow data’s from brand nozzles. When using positive displacement pumps, orifice wear is accompanied by a drop in the liquid line pressure while flow rate remains constant.

Spray pattern

Visual inspection can easily detect 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 revealed until after the flow has increased substantially. Special test equipment is required to check pattern uniformity in case of applications requiring accurate uniformity of spray coverage.

Nozzle alignment

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

Consider alternatives in your present spray system

Take precautions to 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 booster liquid, and changes in the size and/or 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.

Orifice wear and clogging is caused by solid dirt particles in the sprayed liquid in many applications. It’s possible for water to be contaminated with dirt and debris which can cause orifice clogging and/or orifice wear in spraying systems using continuous spray water recirculation. To minimize this type of nozzle problem, line strainers or nozzles with built-in strainers are recommended with a mesh size chosen to trap larger particles which 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 tip surface material. Otherwise, the critical orifice shape or size can be permanently damaged, thereby resulting in distorted spray patterns and/or increased capacity.

Especially, bristle brushed or wooden and plastic probes can be used, while wire brushes, pocket knives or welders’ tip cleaning rasps are to be avoided. In case of 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

A Workshop on spray nozzle maintenance for you and your staff will be personally conducted by us. Included in the workshop is a formidable volume of information on spray nozzle performance problems, causes and solutions. We also address the costs associated with spray nozzles that aren’t performing properly and life cycle cost problems.
Air Mist Nozzles of Secondary Cooling Systems in Continuous Casting Machines

Continuous casting machines are required to cast a wide range of steel grades while maximising production output in state of the art installations. Consistent production of top quality products require increased operational and maintenance flexibility both to the machine elements and control systems and also to the secondary cooling systems, cooling zone positioning, nozzle layout, nozzle selection. The use of appropriate secondary cooling control systems can support these requirements. Optimized down time for maintenance is a key factor in maximising casting output. Implementation of up to date piping header systems and nozzle mounting designs can contribute to minimize secondary cooling maintenance. Modern header systems provide a rigid and self-aligning installation system for nozzles, ensuring nozzle alignment and maintenance accessibility both.

Nozzle characteristics must be investigated. Test procedures are developed to measure cooling patterns and heat transfer. Continuously improved nozzle designs and air/water systems produces a better water distribution. This result in a reduction of surface defects, corner cracking’s and core segregations. Important operational benefits which enables expansion in the product mix and production capacity are also to be considered.

Of particular concern are:
- Water turn-down ratio
- Air-water ratio
- Nozzle type selection to match with the product mix and machine design
- Measured heat transfer coefficients of the spray nozzles
- Over all water distribution
- Maintenance friendly design of nozzle mounting and simple header pipe designs
- Optimized air mist nozzle systems for long product casting.

Water turn down ratio

High turn down ratio of the spray nozzles enables variations in casting speeds (as a result of normal operation practises such as start-up, capping off, revolving ladle or tundish changes and product mix by different steel grades and strand dimensions cast). Control ratio (maximum water flow divided by the minimum water flow) is another term for the nozzle turn down ratio. It defines the range between the minimum and maximum water flow rate over a defined water pressure range of a specific spray nozzle. It is important to indicate the air pressure(s) and/or air pressure control range. Air mist nozzles with a wide turn down ratio will reduce the nozzle varieties in one particular machine at a minimum.

Maintenance and inventory handling department will appreciate this effort both. Nevertheless, it is essential to have a certain number of nozzle varieties in order to fulfil the requirements with regards to the product quality over a wide range of steel grades in modern casters. This happens especially if spray width control (margin control) is needed to control corner temperatures.

Air-Water ratio

The nozzle spray angle and spray height are playing an important role, too because a higher water flow is not the only factor decisive for the heat transfer coefficient. Both determine the spray foot print (width and thickness of spray) and are therefore, factors of the water jet density (water flux) and the jet impact. 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 additionally. Spray cooling on the strand implicates boiling and the formation of a steam layer on top of the steel surface. The compressed air is providing the necessary kinetic energy for penetration of the droplets through this steam layer.
Nozzle type selection to match with product mix and machine design

Layout of the secondary spray cooling system is one of the first steps when a new continuous casting machine has to be 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 has first priority. This process operation is carried out by application of a thermo-mathematical computer model for the calculation of the heat transfer coefficient (HTC) distribution for each steel grade and product dimension. Spray nozzle sizes (flow rates) for each and every cooling zone are established in the next stage of work level. The use of mathematical models bases on actual HTC measurements of spray nozzles. They supply calculations to prognosticate the exact nozzle specification including details such as min. and max. water flows, nozzle pitches, spray heights and nozzle overlaps. Specification of the spray nozzle parameters is influenced by an understanding of the cause of strand defects also.

In a second phase the mechanical design of the machine segments can follow only. This practise underlines the effect of spray nozzle arrangement in general and nozzle design in particular has on the quality of the continuously cast products significantly.

A sound billet, bloom, slab, or beam blank as well as an economical operation are the objectives to be achieved by the spray nozzle cooling system. Nozzle manufacturers must have detailed knowledge of nozzle characteristics under working conditions and the casting segment design.

Over all water distribution

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

Maintenance friendly design of nozzle mounting and simple header pipe designs

Because of their internal mixture, air mist nozzles require one separate supply pipe for compressed air and one for water. Recently it was common to use small diameter hydraulic tubes 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 installation using small pipes is hidden inside the segment rack.

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

Strand surface defects can often be traced back to misaligned or worn out spray nozzles. Header pipes such as shown in Figure 1 are one source of a misalignment. Many small air and water pipes are often out of position due to mechanical impact or thermal reasons. Large numbers of small individually bent pipes are also expensive to manufacture.

Within last few years the vertical segment piping with square or forged air and water main header almost became accepted as an industry standard design. The nowadays with headers equipped air mist nozzle systems are bolted onto adaptor flanges.

Fig. 1: Header pipe with many small, individually bent fluid feed pipes

Fig. 2: Air mist nozzle with vertical plate connection and square pipe header manifold
All nozzle systems are mounted outside of the framework at the colder side of the segment with only the nozzle pipe, carrying feeder tube and spray tip, reaching down to the spray position. A nozzle self alignment is the result by use of very stiff feed tubes. The nozzle spray position is always secured for all normal operation condition. Small diameter fluid feed tubes are no longer necessary.

In order to maintain an identical nozzle length in one segment, the nozzles are bolted onto tailored length adapter plates to compensate the built in bending radius.

Staggering of nozzles is one method to equalize the water distribution along the strand in length direction with the intention to eliminate surface defects and cracks. Since different nozzle positions can be served from only one header pipe manifold nozzle staggering between the roller gaps with in one segment becomes much easier. Figure 4 shows such a design with the left and middle nozzles installed in the same level (roller gap) and the right nozzle in the level above and below.

**Nozzle and Tip Alignment**

Correctly aligned and within the segment of the piping system/headers well adjusted spray nozzles are of outmost importance.

Misaligned and off position air mist nozzles can often be seen. The spray is colliding with support roll so reducing their cooling efficiency.

Spraying Systems nozzle tips are equipped with a standard dove tail fixation. It ensures correct positioning of the spray tip and hence the correct spray direction and adjustment. Tolerance for maximum installation misalignment is 3°. Dove tail fixation is important for error prevention.

**Nozzle Body Interface**

Nozzle header mounting surface and counter flange has to kept clean and free of marks in order to ensure a proper and leakage free connection. Please make sure that new o-rings are being used whenever the nozzle is removed for a major repair or off site maintenance. It is also important that the plugs tightened by undamaged copper seals. Checking taps for water and air supply allow easy and fast maintenance.

**Air and Water Filtration**

Spraying Systems recommends maintaining the following air and water quality by means of applying the appropriate utilities.
Air Mist Cooling Air Supply

- Dew point 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 0.2 MPa 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 (SO4) 500 ppm
- Chloride (Cl) 250 ppm
- Silica (as SiO2) 150 ppm
- Carbonate Hardness (CaCO3) 300 ppm
- Total Hardness (CaCO3) 1000 ppm
- pH 6 to 9.5
- Free Oil 5 ppm
- Dissolved Oil 10 ppm