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ELIMINATE OXIDE DUST WITHOUT COMPROMISING PRODUCT QUALITY[1]

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Abstract
Oxide dust generated from the rolling process is a big problem for most rolling mills, especially those rolling high silicon or high carbon products. A system has been developed to effectively control the oxide dust from the rolling operations and is robust enough to change operating conditions to adjust to different rolling parameters. Effective control of the oxide dust significantly reduces maintenance time required to clean and/or repair equipment that becomes covered and prevent damage to electrical equipment, not to mention improves worker safety. The system utilizes an air and water mixture with specifically proportioned design to encapsulate and control dust particles without affecting cooling or quality of the rolled product. This paper will discuss the features of the system and follow several successful installations.
Keywords: Hot rolling; Oxide dust; Suppression spray systems.

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1 INTRODUCTION

During hot rolling of steel – primarily high carbon or silicon steel, a significant quantity of oxide dust is generated. This dust is troublesome and there have been many attempts to control it. Within this paper, the subject of rolling oxide dust suppression will be addressed including key factors that must be recognized and controlled for proper results from the suppression system.

2 TYPICAL SCENARIO FOR OXIDE DUST GENERATION

Oxide dust is generated during hot rolling – it can be present in varying quantities and characteristics depending upon alloy, temperature, and rolling speed. Normally, the worst areas for dust generation are the final three to four finishing stands of a continuous finishing train, or successive passes of a reversing Steckel mill or plate mill. It is at this point in the rolling process that strip speed is also the fastest, which causes a natural "fan" phenomenon – blowing the dust throughout the mill bay, and covering all equipment within reach.

3 PROBLEMS CAUSED BY OXIDE DUST

With large quantities of Oxide Dust emitted into the mill bay, there are several problems and concerns that need to be addressed.

- Visibility – in many cases, there is so much dust generated that it causes poor visibility of the mill for operators.
- Cleanliness – Oxide dust routinely coats all equipment requiring that frequent mill clean-down via high pressure sprays will be necessary.
- Electrical – Dust accumulates on crane rails to a significant depth of several inches. In addition, the conductive dust also poses a problem for some electrical equipment and causes electrical short issues.
- Strip surface – If not controlled, oxide dust will be rolled in on succeeding mill stands or passes. This affects the purposeful oxide layer generation on the rolls, as well as the strip surface – through rolling of the fine dust through the mill bite.
- Operator environment – Operators report problems with breathing or functioning within the extreme dust environments near the oxide dust emission.

4 ATTEMPTS AT A SOLUTION

Regarding attempted remedies, there are a few themes that tend to be used in variation. One of the most prevalent is to attempt dust remediation through water sprays that are directed from the side towards the exit of a mill stand. A variety of water pressures, sometimes combined with compressed air or steam, have been employed with the intention of causing a spray barrier through which the dust hopefully cannot pass. When attempting this solution, spray nozzle positioning and quantity are variables that most mills will routinely adjust to gain better performance. Of course, any nozzles must be positioned to reach the dust, yet remain protected from the rolling process and out of the way of roll changes or equipment maintenance. Overall, this method has met with limited success. A variation of this

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is to mount nozzles in between bays above and around the mill stands as an attempt to capture the dust and knock it down. This may be successful for certain grades and line speeds, but often as operating parameters change, the dust control system becomes ineffective.
Some mills have attempted to capture escaping dust through the use of exhaust hoods. This method has also met with limited success because of the large hood flows that must be generated, and the tendency for damage that can occur to a hood structure within the confines or near proximity to a hot mill stand. This is especially true when hoods are installed by the end-user as an after-thought compared to an exhaust system installed by the OEM.
Another attempt at remediation includes embedding nozzles directly in the mill exit stripper plates. While this idea has merit, serious issues can arise if all the factors are not properly considered during design and installation of the system. Problems include induced thermal variation across the strip, insufficient dust removal, persistent nozzle and system plugging, and difficulty with maintenance. The maintenance issue is particularly acute due to the tendency of stripper plates and all components mounted thereon to suffer severe damage during cobbles. Please refer to Figure 1, which indicates strip thermal variation (or, striping).

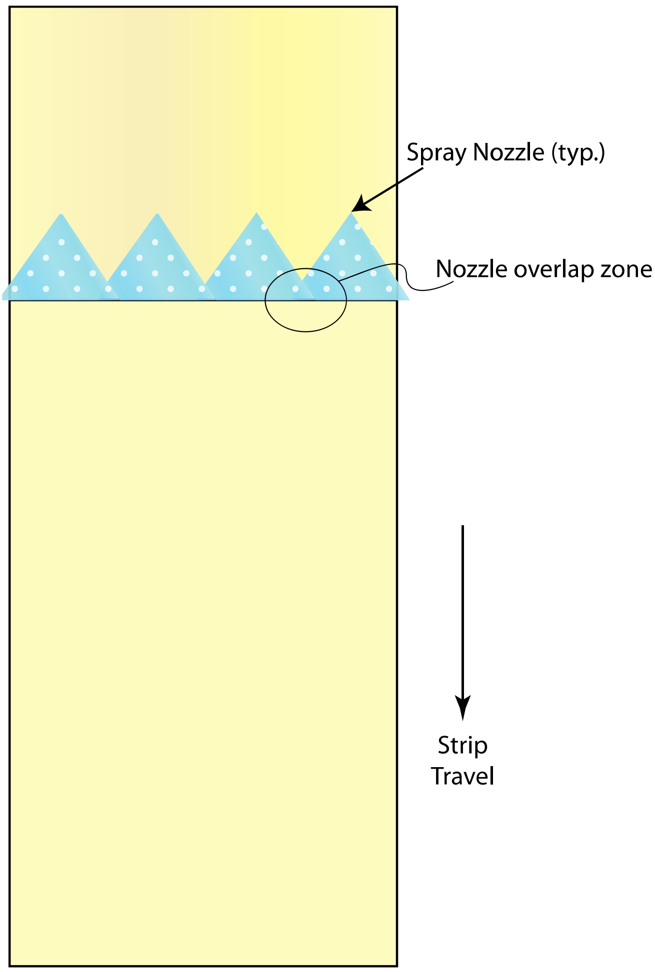

Figure 1: Thermal variation across the strip.

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5 SPRAYING SYSTEMS CO. OXIDE SUPPRESSION

The technology developed and employed by Spraying Systems Co. to address the issue of oxide dust suppression has been used for many years. Recent advancements also are incorporated that will provide further benefits to the mill for operation and control.
Key concepts which guide system design are:

1. Adaptable for existing mill strippers and layouts
2. Utilize nozzles designed for dust control
3. Provide adjustment for operating conditions
4. Complete coverage of the "critical zone" – area where oxide dust is generated
5. Suitable mechanical design for hostile hot strip mill environment
6. No introduction of cooling variation across the strip
7. Ability to perform maintenance
8. Filtration

The general approach to oxide dust suppression involves appropriate nozzle selection, proper placement of nozzles, and integrated control that adjusts mist based upon operating conditions. These aspects to a successful system are now considered separately below. Please refer to Figure 2, which indicates strip with proper mist generation techniques and the absence of induced thermal variation. This illustration may be considered in light of the discussion below.

5.1 Nozzle Selection

The most important aspect of dust control is to understand the relationship between the dust particles and the droplets trying to capture them. The droplets generated from the spray nozzles must be comparable in size with the dust particles in order to collide with and fully capture them. If droplets from the spray nozzles are too large, dust will simply follow the air stream around the droplet and escape. If droplets are too small, the particles will bounce off or move past the spray droplets. See Figure 3 for a visual image of this phenomenon. Effective dust control occurs through the proper mixing of air and water, under the correct conditions of pressure, velocity, and nozzle chamber and orifice design. When controlled and combined correctly, the result is a repeatable even mist of known density and particle distribution. This mist is then ideally suited to collide with the oxide dust particles and to provide efficient capture. The available turn-down ratio of the air mist nozzle assembly provides the capability of control based changes to accommodate varying alloys and/or operating conditions. A unique dual-chamber header is used as a feed mechanism to the air mist nozzles. Because cooling is not desired with this system, an absolute minimum of water is used.

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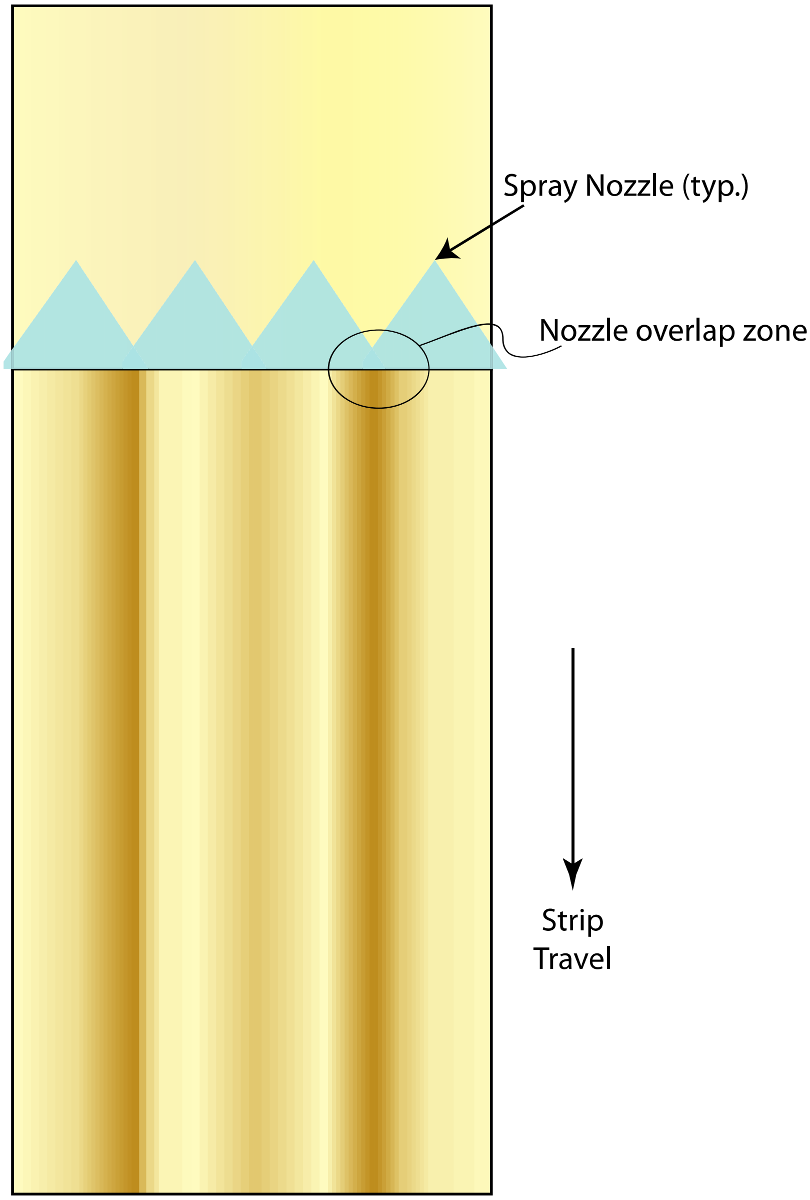

Figure 2: Strip with proper mist generation.

5.2 Proper Placement of Nozzles

Importance of spray nozzle selection cannot be overstated, but correct placement of the nozzle is of equal importance. The spray nozzle must be located where the dust is created – near the exit bite of the work rolls. Identified as the “critical zone”, the area where the dust is generated and emitted is to be surrounded on its entire periphery – which results in the best overall suppression.

If stripper plates are utilized, they will need to be machined to accommodate the nozzles. The nozzle bodies will be mounted on top of the stripper plate while the tip will go through the plate and positioned such that it will spray the mist directly into the bite, however it will be recessed to protect it from any cobbles or wrecks that may occur. See Figure 4 for an illustration of nozzles mounted in a stripper plate guide at the exit side of a mill stand.

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When the drop diameter is bigger than the particle diameter, the dust particle will follow the air stream around the drop.

When the drop and particle diameters are comparable, the dust particle will follow the air stream and collide with the drop.

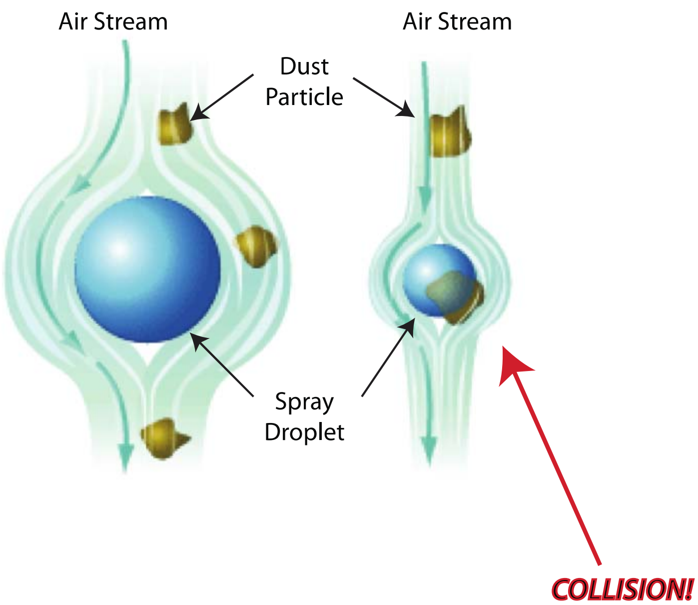

Figure 3. Dynamics of dust capture through proper mist generation.

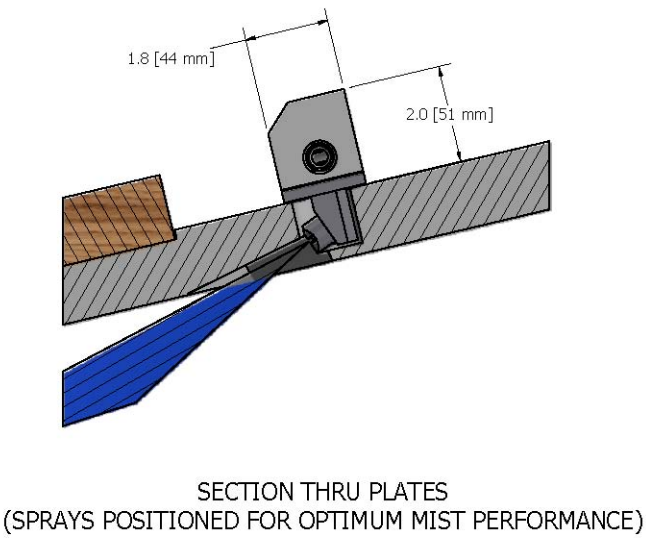

Figure 4 – Side view of nozzle placement in a stripper plate.

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5.3 Suitable Mechanical Design

Because of the hostile environment within and near a hot mill, all design aspects must take this into consideration. In particular, construction techniques must limit the potential for internal scale buildup (source of nozzle plugging), and provide means of flushing or cleanout as needed.
Routinely, tight confines will restrict the ability of maintenance personnel to service the system properly, so consideration must be taken into account right from the start for this concern. On mills where bottom strippers are segmented – i.e., a set of parallel plates rather than one solid assembly, the spray nozzles and system need to accommodate the potential individual movement of this configuration. It is of high importance to provide mechanical protection to the nozzles, but not to introduce any potential impediment to proper strip travel or operation.
Finally, customizing some of the operating procedures can also be effective in combatting the introduction of scale internally to the nozzles, in combination with good design practice.

5.3 Filtration

Without a doubt, water and compressed air quality in the hot mill environment is routinely very poor. Even with all careful consideration given to design, there is no alternative to proper filtration of the incoming air and water. A proper control strategy will monitor these values for correct operating ranges, and alert as needed for maintenance.

6 RESULTS AND DISCUSSION

By analyzing several mill installations of this system, it is apparent that the design thus presented is effective at generating a mist shield that removes the oxide dust – without cooling the strip. Further, even though hard to quantify, workers estimated that their work environment improved substantially – in the most extreme cases, the mill became visible again even when running high carbon or silicon steels.
Accumulation of dust on crane rails was significantly reduced – now going on two years. The associated cost of accumulated dust removal on both crane rails and the mill equipment overall has been reduced to approximately 20% of the original costs. These values are dependent upon the product mix being run on the mill.
One of the most important benefits of the system is the reduction of surface pitting that had previously occurred prior to the installation of the Oxide Dust Suppression system. Current surface pitting from rolled-in dust has dropped by 75% in some cases.
Please consider accompanying photographs, Figure 5 shows the conditions before the Oxide Dust Suppression system is turned on. Figure 6 shows the conditions after the Oxide Dust Suppression system is turned on. This mill, in the Mid-Atlantic region of the US, has seen exceptional results from this system over several years.

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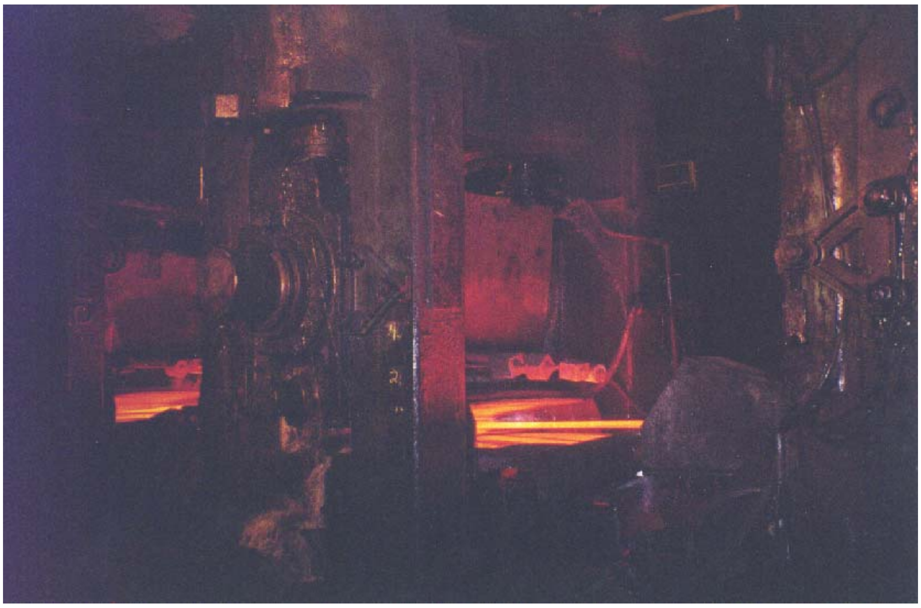
MILL STAND DELIVERY
Figure 5. Oxide controls turned off.



MILL STAND DELIVERY
Figure 6. Oxide controls turned on.

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7 SUMMARY

The process of successful oxide dust suppression on hot mills and Steckel mills can present its own set of challenges. No system has proven to eliminate 100% of generated oxide dust. Although the vast majority of dust can be captured with a good system, dust emission from around roll journals and directly up through the top of a mill stand cannot typically be captured. Several attempted solutions have been discussed, and the system from Spraying Systems Co. has been specifically addressed for its unique approach in mist generation and suppression. Spraying Systems emphasizes a comprehensive approach in design and implementation, resulting in a system that facilitates maintenance and provides successful long-term operation.

The information presented has been proven based on years of system installations and actual user feedback. Proper oxide dust suppression will significantly improve the worker and mill environment, and result in a higher quality product.