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IMPROVING DESCALE PERFORMANCE WITH THE DESCALEJET® PRO*

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Abstract

Spraying Systems Co® has continued to develop and evolve descale nozzles through the years. The most recent addition to the descale nozzle line, the DescaleJet® Pro, provides more impact and a more uniform distribution than previous descale nozzles. The improved performance has been achieved through multiple design changes such as a smoother approach, updated vane design and improved carbide orifice. In addition to providing improved spray performance the nozzle also lasts longer than previous versions. The new technology has been thoroughly tested in the lab using impact measurements and accelerated wear testing. In addition to lab testing the nozzle has provided improved performance and longer wear life for those that have made the change to the new technology. The new nozzle technology and the benefits to the rolling mill will be discussed.

Keywords: Descale; Rolling mill; Impact.

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1 INTRODUCTION

Hot strip mills use high pressure hydraulic nozzles in the descaling process to remove scale from the steel surface. It is important to remove the scale to prevent defects in the material and to increase the life of the rolls. This scale is formed by a direct reaction of metal with oxygen, water and other elements. The type of scale formed will depend on a number of factors including- base material, temperature, time in the furnace and type of furnace. In theory the spray cools the outer scale layer causing a temperature difference between the base material and the scale. This causes the scale to create cracks and allow the spray to penetrate through the scale. The water then turns to steam and helps to lift the scale from the base material. Lastly the sprays push the loose scale off of the surface of the steel. Through the years the nozzle design has evolved to provide a more efficient impact profile. The most recent nozzle development the DescaleJet® Pro provides more impact and longer wear life compared to previous designs.

2 BACKGROUND

Original dovetail nozzles used for descaling were little more than flat spray nozzles with a tungsten carbide insert. These nozzles provided longer wear life at the high pressures but did little to reduce turbulence and frictional losses inside the nozzle. In addition early descale nozzles did not offer an integral strainer so nozzles frequently became plugged. The 1st generation descale nozzle provided a flow straightener behind the nozzle orifice. This worked to help straighten the flow which improved the impact of the nozzle. Even further improvements were made with the second generation nozzle. This nozzle had a more streamlined high impact attachment and the high impact attachment included a strainer.
However no nozzle can exceed the total theoretical force and it is the same for all nozzles of the same flow rate and pressure. The maximum force a nozzle can produce is governed by the equation:

$$I_T = \rho Q V$$

$I_T =$ Total Impact Force
$\rho =$ Density
Q= Flow Rate
V= Velocity

In order to reach this maximum force the nozzle needs to be optimized to reduce as many losses as possible.
The latest development, the DescaleJet® Pro, further improves descale nozzle technology. The DescaleJet® Pro has

- Updated vane design;
- Wider orifice cut for a wider effective coverage;
- Larger internal area for reduced frictional losses and increased impact;
- New carbide material for longer wear life.

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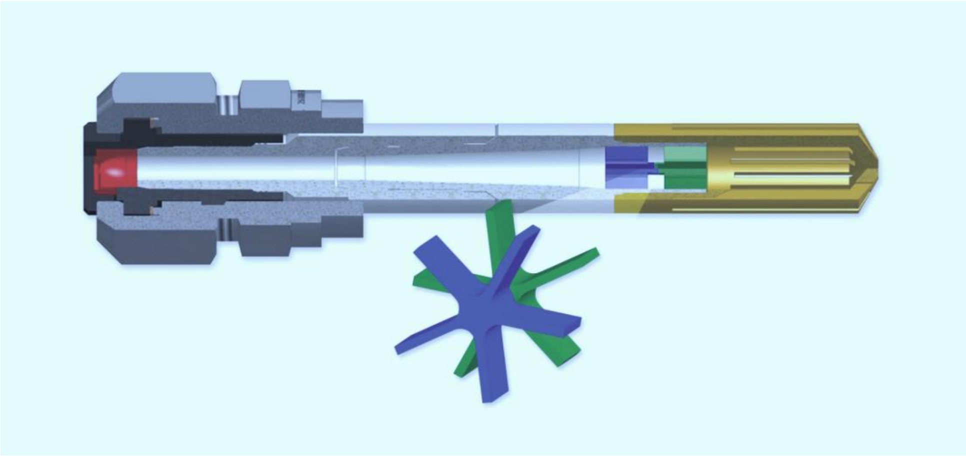

Figure 1: DescaleJet Pro section view

2.1 DescaleJet® Pro Improvements

Vanes are used in descale nozzles to help straighten the flow before it reaches the nozzle exit. In descale header design the flow enters the nozzle 90 degrees to the nozzle exit. The flow then turns and travels a short distance to the nozzle exit. The bend in the flow path creates turbulence in the flow and needs to be eliminated or reduced in order to optimize the impact force of the nozzle. If the turbulence is not reduced before exiting the nozzle the result will be low impact levels. High turbulence before the nozzle exit can reduce impact levels up to 50%.

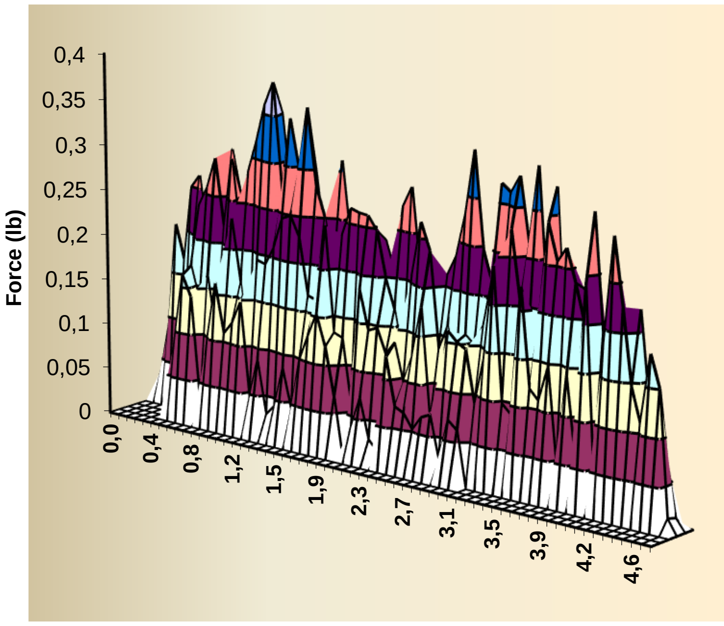

Figure 2: Impact graph for descale nozzle with no high impact attachment

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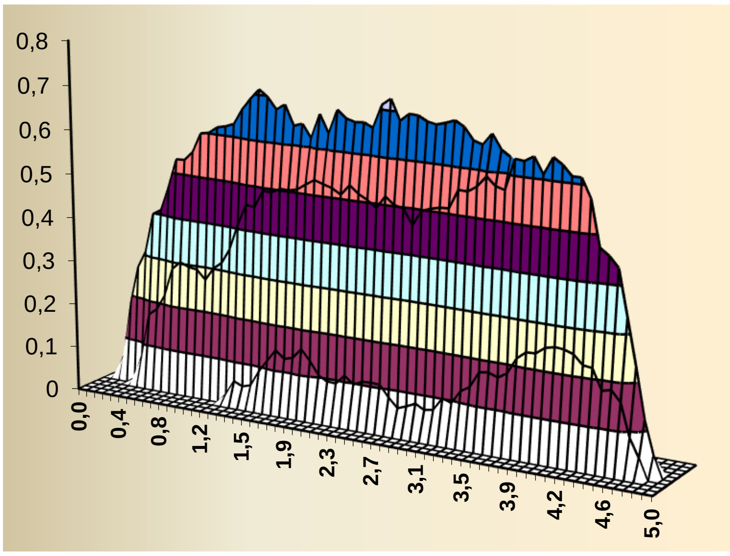

Figure 3: Impact graph for same nozzle as in figure 1 with high impact attachment

The DescaleJet® Pro uses a two vane configuration with a total of ten offset fins. The number of fins is increased by a total of four compared to the 2nd generation descale nozzle. In addition to the greater number of fins the overall length of the vane approach has increased providing a longer flow straightening distance. The levels of turbulent kinetic energy in the DescaleJet® Pro are shown in illustration 4.

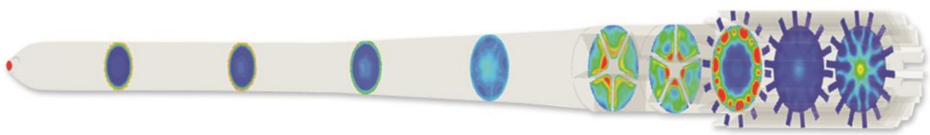

Figure 4: CFD Analysis of turbulent kinetic energy in the DescaleJet® Pro

The highest amounts of turbulent energy are seen at the top of the strainer where the flow bends 90 degrees. As the flow passes through the two vane configuration of the DescaleJet® Pro the turbulent energy is reduced. As flow moves closer to the orifice the levels of turbulent energy have been reduced two levels of magnitude.

The wider orifice cut provides a wider effective coverage compared to previous versions. A wider effective coverage is beneficial because there are higher impact levels at the edges of the spray pattern. This will allow the nozzles to be placed closer to the steel surface and further apart from each other. This also reduces the amount of water in the overlap area and reduces the risk of overcooling in the overlap zones.

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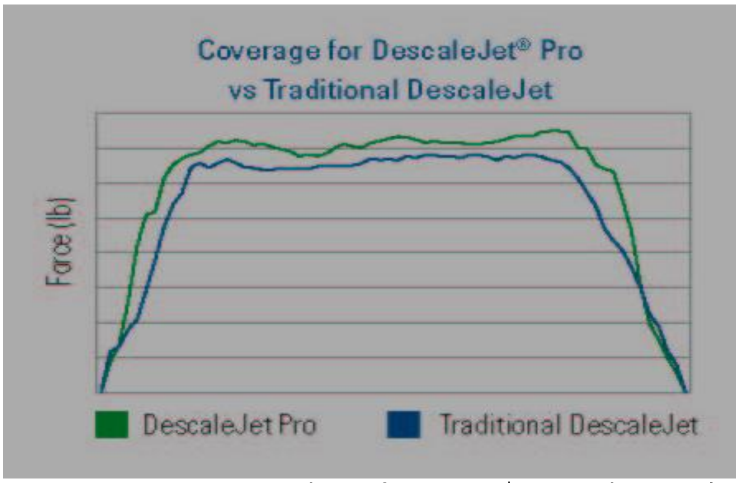

Figure 5: Coverage comparison of Pro vs 2^{nd} generation nozzle

The internal diameters of the DescaleJet® Pro have been increased. By increasing the internal area the frictional losses are reduced and more of the force of the spray is maintained when it exits the orifice. The end result is a higher impact force.
In order to determine how much more impact the DescaleJet® Pro produces impact testing was done using a patented process to measure the load throughout the entire spray pattern. A small pin is attached to a load cell which moves through the spray in an X-Y grid pattern and is controlled by two servo motors. The force of the spray pushes down on the pin and the data is collected by a data acquisition system. The end result is a complete picture of the force profile of the spray pattern.

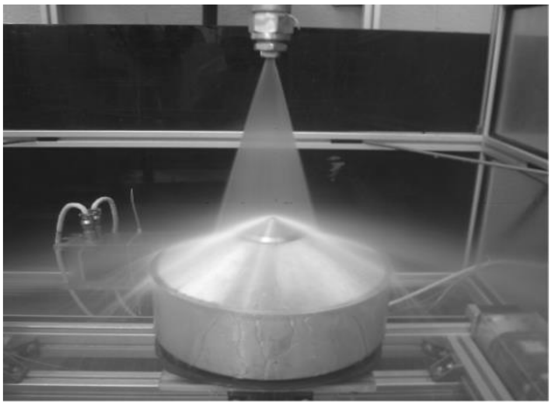

Figure 6: 3-D impact testing device

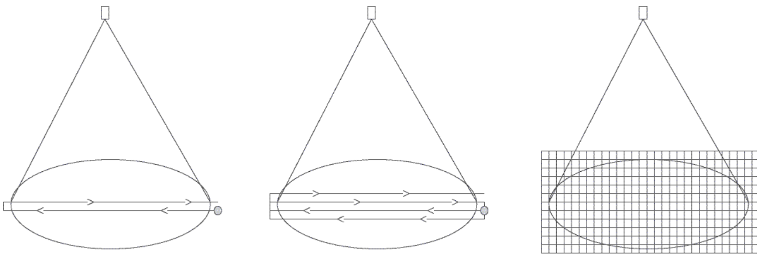

Figure 7: Movement of load cell underneath spray pattern

The impact testing device was used to measure the impact force of the dovetail, 1^{st} generation, 2^{nd} generation and Pro DescaleJet® nozzles. The DescaleJet® Pro provided higher impact values than all previous versions.

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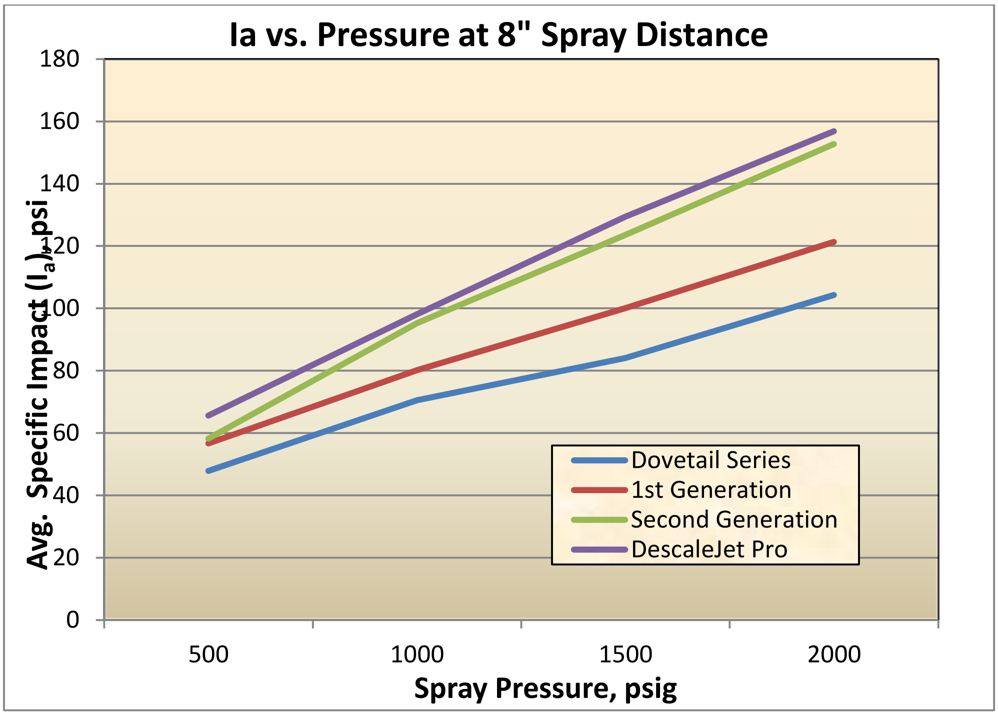

Figure 8: Impact vs Spray Pressure at a constant spray height

Mill A had replaced the 2nd generation nozzles with the DescaleJet Pro nozzles. The DescaleJet Pro nozzles provided the same coverage and flow rate of the previous nozzles and were placed in the same header. The mill saw a significant increase in impact resulting in cleaner steel. The mill is now considering reducing the amount of water being used to achieve a similar impact level with the DescaleJet Pro as with the 2nd generation nozzle; however that project is still ongoing while the mill researches the affect the reduced water will have on the temperature of the slab. It is important to consider how changes in the descale process will affect the overall performance of the rolling mill.

Improving the carbide in the nozzle orifice has allowed for longer wear life. This has been proven under laboratory conditions and mill applications. Under laboratory conditions a slurry mixture was sprayed through both the DescaleJet® Pro and the second generation descale nozzle. Identical sizes were used for each nozzle series. The test was stopped every hour and the nozzles were checked for both flow rate and spray angle at 40 psi. The test was run until the flow rate of all nozzles had reached 15% above the original flow rate.

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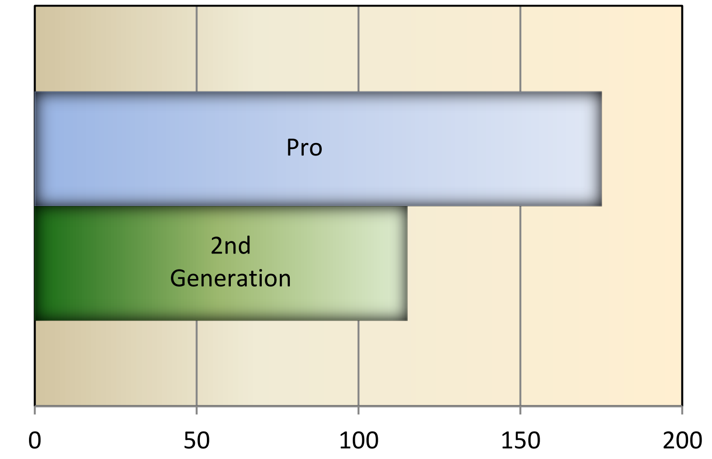

Figure 9: Time to reach 15% above initial flow rate during accelerated wear test

The DescaleJet® Pro lasted 1.5 times longer than the previous descale nozzle series. This indicates that a mill will be able to go longer between nozzle changes. This will allow the mill to run more tons without having to stop to change nozzles.

Mill B was able to see this improvement. Previously they had been using the 2nd generation descale nozzle in their roughing descaler. After switching to the DescaleJet® Pro TC3230E nozzle they were able to see a 30% increase in wear life. No change was made to the water quality at this time. The increased wear life can be attributed to the improved carbide material. Improving the wear life of the material has allowed this mill to run longer and see improved descale quality over a longer period of time.

2.2 Summary

The DescaleJet® Pro has improved and enhanced descale nozzle technology in the rolling mill. When using the DescaleJet® Pro a mill will benefit by having a wider effective coverage, higher impact and a longer wear life. This will allow a mill to run the descale header more efficiently and longer than with previous nozzles.