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Experts in Spray Technology

— TECHNICAL BRIEF —

# OPTIMIZING SECONDARY COOLING IN CONTINUOUS CASTING

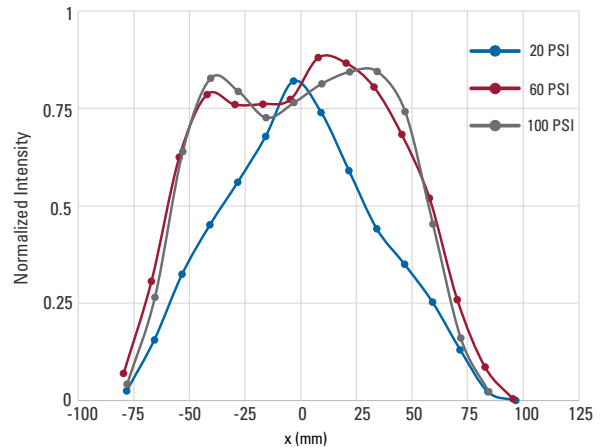
## INTRODUCTION

Secondary cooling in continuous casting is an important process. The nozzles in the secondary cooling process directly affect solidification and product quality. As casting speeds increase and mills are producing more grades of steel, the flexibility and efficiency of the secondary cooling system become even more important. Hydraulic full cone nozzles are used in all types of casting machines. The nozzles need to be robust to handle the environment and provide consistent performance to maintain constant cooling over the working range of the machine.

Historically, nozzles used in billet casting and the upper sections of slab casters were full cone nozzles with either round or square patterns. See Figure 1. Casters ran slower, and mills weren't running as many grades of steel as they do today.



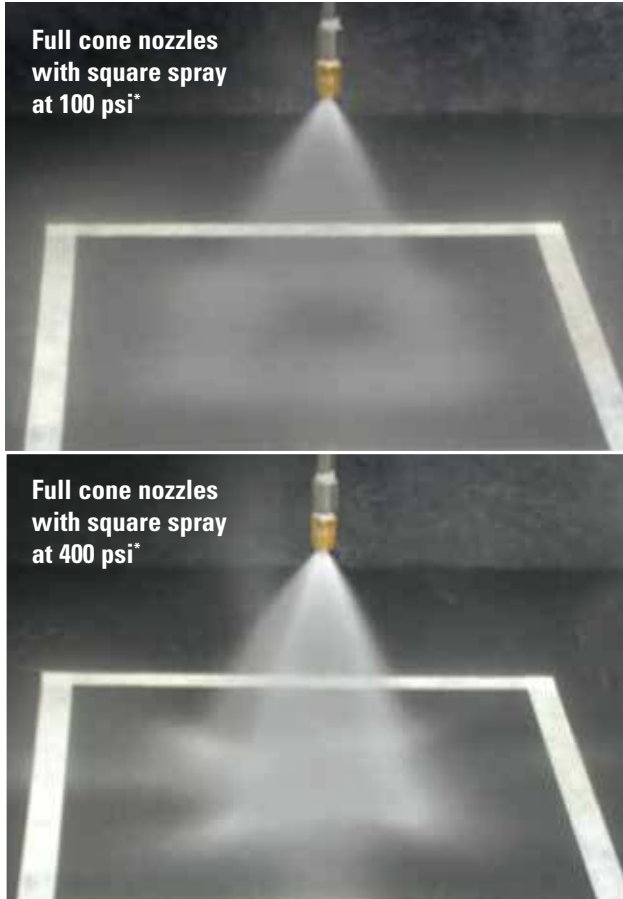
**FIGURE 1:**  
Traditional full  
cone nozzles



**FIGURE 2:** Standard FullJet® full cone nozzle distribution at various pressures

Traditional, round full cone nozzles have variations in coverage and distribution as the pressure changes. As shown in Figure 2, the coverage at 20 psi is lower than the coverage at both 60 and 100 psi. In addition, the distribution profile changes as the pressure changes. The change in coverage is also visible in the spray pattern. At higher pressures, the distribution is more uniform.

Another common spray pattern used in older casters is the square pattern. Nozzles with square patterns fit nicely between the rolls in the upper section of the slab caster and were perceived to fully cover a billet without any overspray. However, the square pattern is easy to misalign during installation and often misses the targeted spray area, resulting in hot spots. Another issue with full cone nozzles with a square spray pattern is that they rotate as pressure increases. And, at higher pressures, the square spray pattern turns into a star-shaped pattern as shown in *Figure 3*. In addition, the outer profile of these nozzles create maintenance challenges. These nozzles are typically recessed and installed behind guards. Mold flux and other debris in the caster can fall through and collect on the flat profiles on the outside of the nozzles. The flat surfaces on the outside of these nozzles make the traditional full cone nozzle an easy target for debris to collect.



**FIGURE 3:** Side-by-side comparison of FullJet® HH square spray full cone nozzles at 100 psi and 400 psi.

\* Note the difference in spray pattern and spray orientation.

## NEW NOZZLE DESIGN PROVIDES IMPROVED PERFORMANCE

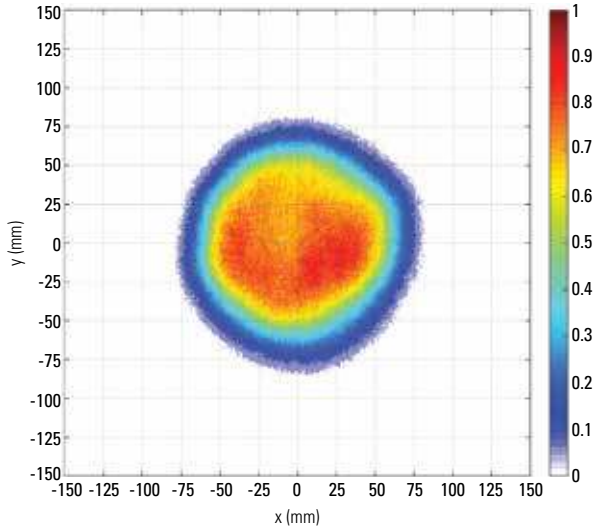
New HHX FullJet nozzles have a low profile and socket design as shown in *Figure 4*. The low profile allows the nozzles to sit close to the header to help prevent debris from collecting or falling on the nozzle. The socket design provides easy installation with standard tools. The vane, an integral part to creating the uniform coverage, is staked in place. This ensures proper spray during the life of the nozzle in the high heat environment.



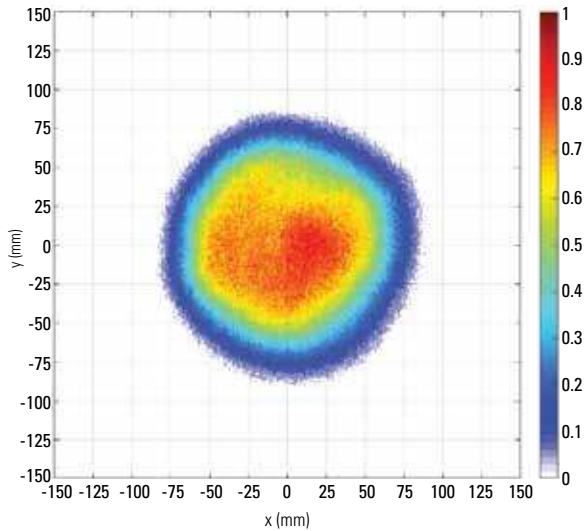
**FIGURE 4:** New HHX FullJet round spray nozzles in 1/4", 3/8" and 1/2" sizes.

In addition to the physical design, the performance is now more aligned with the requirements of newer casters and the secondary cooling process. HHX FullJet nozzles are available in a wide range of spray angles and capacities. Nozzle capacities can be changed without making major changes to the manifold or segment.

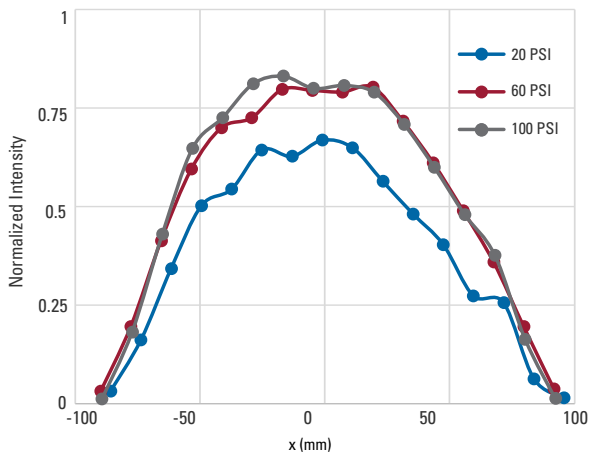
Cooling is the main goal of the nozzle. As casting speeds increase and steel grades become more complicated to cool, a nozzle that provides consistent coverage even during pressure changes become necessary. Liquid volume is the driving force for heat transfer. Areas of high liquid concentration have high heat transfer rates. Therefore, it is important to have uniform, consistent distribution in cooling nozzles. *Figures 5 and 6* compare the traditional full cone nozzle distribution with the distribution of the new HHX FullJet nozzle. The HHX FullJet nozzle provides more uniform distribution over the pressure range of the nozzle. As shown in *Figure 7*, the HHX FullJet nozzle has no variation in coverage from the low operating end to the high operating end.



**FIGURE 5:** HHX FullJet® nozzle distribution measured by laser sheet analyzer



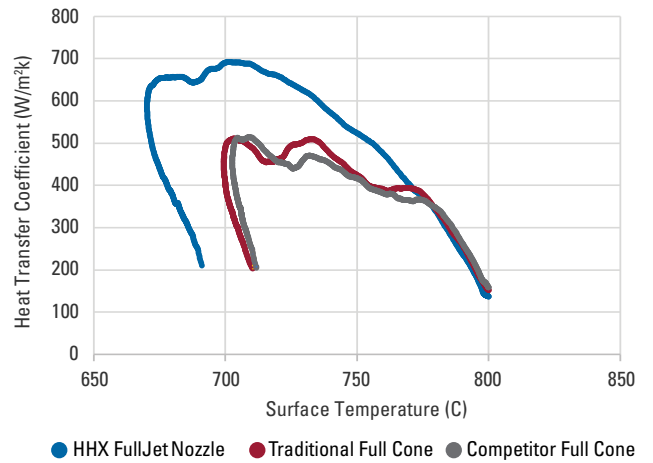
**FIGURE 6:** Traditional full cone nozzle distribution measured by laser sheet analyzer



**FIGURE 7:** HHX FullJet nozzle distributions at various pressures

## BETTER HEAT TRANSFER EFFICIENCY

Independent testing was conducted to determine the heat transfer coefficient (HTC) values for various full cone nozzles. The testing involved heating a sample with inductive heat. Once the sample reached the start temperature, it was moved through the spray pattern with a defined velocity. Inside the cylinder, several thermocouples recorded the temperature. From this data, shown in *Figure 8*, the HTC value was calculated using inverse conduction. The HHX FullJet nozzle series had higher HTC values over traditional full cone nozzles. The maximum HTC value measured is 34% higher than both the traditional HH full cone and competitor full cone nozzles.



**FIGURE 8:** Heat transfer coefficient vs. surface temperature comparison for HHX, traditional HH and competitor full cone nozzles

## CONCLUSION

Modern casting requires machines to run more grades at faster speeds. A full cone nozzle with a consistent, uniform coverage and distribution is crucial for the secondary cooling process. Achieving cooling curves necessary for increased casting speeds and increased steel-grade ranges is possible with the HHX FullJet nozzle. The HHX FullJet nozzle provides a low-profile stacked-in vane design with consistent coverage and high heat transfer rates.



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