Masoneilan
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White Paper

DSH-1XX, In-line Radial Design Desuperheater

Steam Conditioning Valves and Desuperheaters

Advanced Spray Water Injection, Mixing and Evaporation Techniques

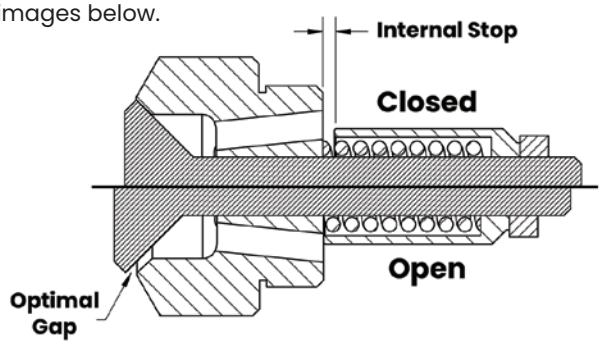
Masoneilan™ attemperators operate by injecting high velocity spray water into superheated steam, shearing the droplets and promoting heat transfer thereby boiling and evaporating the water droplets.

Spray water nozzles and droplet creation

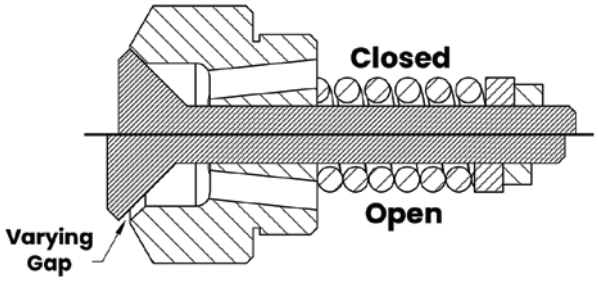
Masoneilan spray nozzles have been validated through laboratory testing to measure droplet size and distribution using a doppler laser particle analyzer. Using such state-of-the-art equipment ensures the nozzles are delivering a suitable spray pattern and distribution to provide an evenly distributed temperature gradient across the steam pipe for proper cooling.

The mean droplet diameter is less than 100µm with over 99% of the droplets less than 200µm in diameter.

These values remain consistent regardless of the flow rate through the spray nozzle due to a unique design feature. Once the pressure across the spray nozzle reaches 1.7 bar (25 psi), the nozzle is fully open against an internal mechanical stop and remains this way throughout the range of pressure drops and flow rates. This fixed nozzle area gives a very consistent spray pattern and size distribution under all conditions. Other manufacturers provide nozzles that increase the open flow area continuously with pressure, which creates conditions ripe for spring fatigue and inconsistent spray parameters as shown in the images below.



Masoneilan Nozzle Design



Competitors Nozzle Design

Spray Water Injection

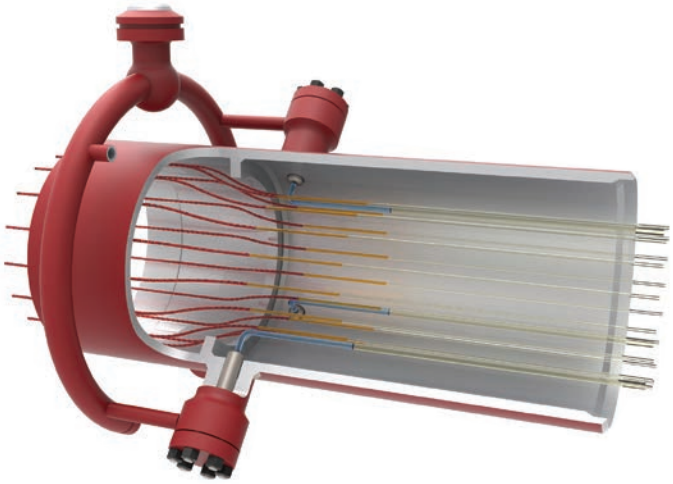
Droplets are injected into the high velocity steam flow where they are sheared and broken up. The effectiveness of the secondary shearing is determined by the Weber number, a dimensionless number relating the dynamic forces of the steam to the surface tension of the droplet. Weber numbers below 10 indicate that a droplet will not break up. Typically, the Weber number of our steam-spray water system is above 300 and frequently reaches 600 indicating excellent shearing and enhanced heat transfer.

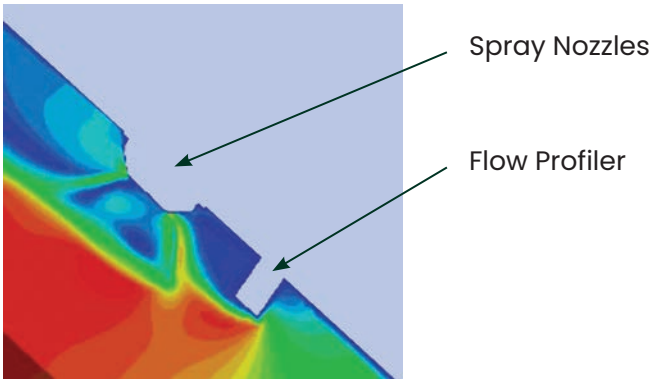
Flow profiling

High thermal stresses are common in steam conditioning and desuperheating applications, where cooler water is injected, often in very high volumes, into superheated steam pipes. As the spray water impinges against high temperature pipe surfaces, thermal stresses are created that over time can quickly lead to pipe failure and cracking.

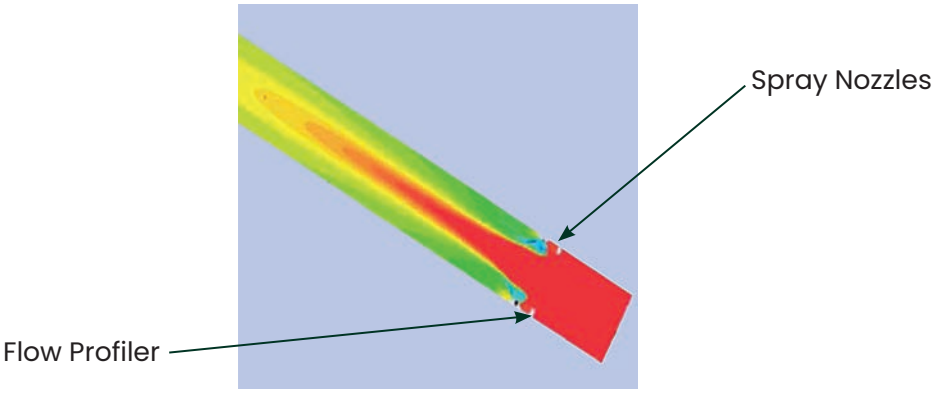
Through patented research and testing, Masoneilan has enhanced the water injection system within steam conditioning valves and desuperheaters, which are now designed with a flow profiling ring upstream of the spray nozzles. This patented feature diverts the flow of steam away from the pipe wall and toward the center of the pipe, thus improving mixing within a more turbulent area and reducing transient thermal stresses, as demonstrated in the images below.

The Flow Profiler also diverts the flow from the spray nozzles which protrude slightly from the inside diameter of the pipe. Designs without a flow profiler introduce steam impingement directly against the spray nozzles themselves, creating thermal stresses in the nozzle components, which can lead to even more severe damage should a nozzle fail in service and potentially overheat downstream equipment.





CFD analysis showing Flow Profiler and spray cone.



CFD analysis showing high temperatures contained away from the pipe wall.

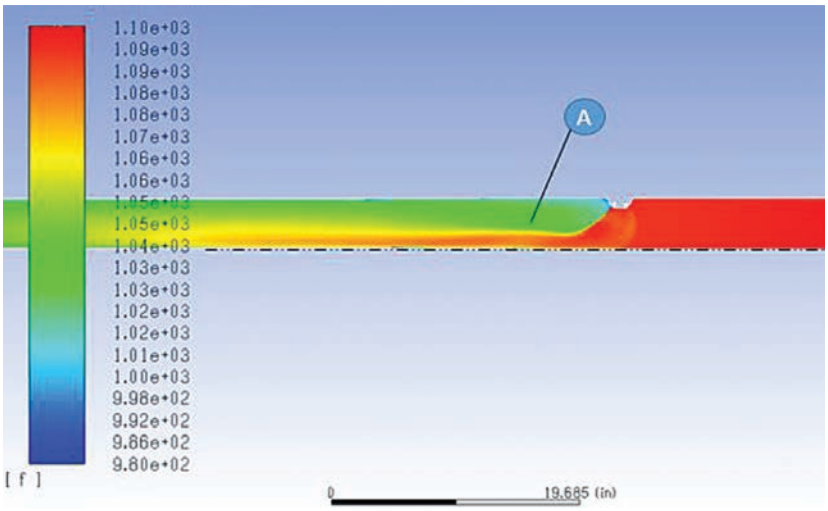
Heating and evaporation

The industry uses rules of thumb to specify the location of the downstream temperature sensor. These sensors are typically specified as fixed lengths but do not account for differences in droplet size, steam superheat or spray velocity.

Knowing the droplet size accurately allows calculation of the temperature sensor location using thermodynamic and heat transfer equations. The time to evaporate a droplet is comprised of the time to bring the full surface area of the droplets to boil via convection, plus the time to fully evaporate the droplet at saturation conditions. This is an integral equation accounting for the change in droplet diameter with respect to time as the droplet evaporates. Masoneilan has developed this proprietary method to account for all the process variables.

Attemperator pipe liner

The benefit of the patented Flow Profiler is that it often replaces the need of an additional pipe liner in the system. However, in many applications, such as boiler attemperators, a thermal pipe liner may be requested by the customer to account for extreme quantities of water injection that may overwhelm even a well-designed thermodynamic system. If a pipe liner is requested, Masoneilan recommends 1 meter up to 2 meters of length after the spray water nozzles. Each application can be reviewed given the specific process conditions to determine an optimal length.



CFD showing the length for the thermal jet to fully diffuse.

Conclusion

Through years of experience in steam conditioning, Masoneilan has evolved and patented technology to optimize the efficiency of steam desuperheating and extend the service life of steam conditioning equipment. Field and laboratory proven trials have given extensive analysis of various technologies to help optimize water droplet size, spray nozzle location, and upstream flow profiling to provide a consistent temperature gradient across the pipe and prevent thermal stress, or high cycle fatigue along the downstream pipe walls.

Each application comes with unique process conditions, and can be evaluated by steam conditioning experts to optimize the right equipment for the service.

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