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Nozzle Assembly With Single Inlet And Dual Outlets For Roll Cooling Spray Headers

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NOZZLE ASSEMBLY WITH SINGLE INLET AND DUAL OUTLETS FOR ROLL COOLING SPRAY HEADERS

Cooling spray headers for a rolling mill work roll include a plurality of nozzles, and the cooling spray header is configured to apply a pressure and flow rate to each nozzle such that the resulting spray pattern from the nozzles will provide cooling along the width of the roll. A cooling spray header commonly includes three zones of nozzles – a middle zone includes nozzles that have a nozzle spacing of 52 mm between each nozzle, and side zones on either side of the middle zone include nozzles that have a nozzle spacing of 26 mm. The below figure illustrates an example of a traditional cooling spray header with a middle zone and two side zones.

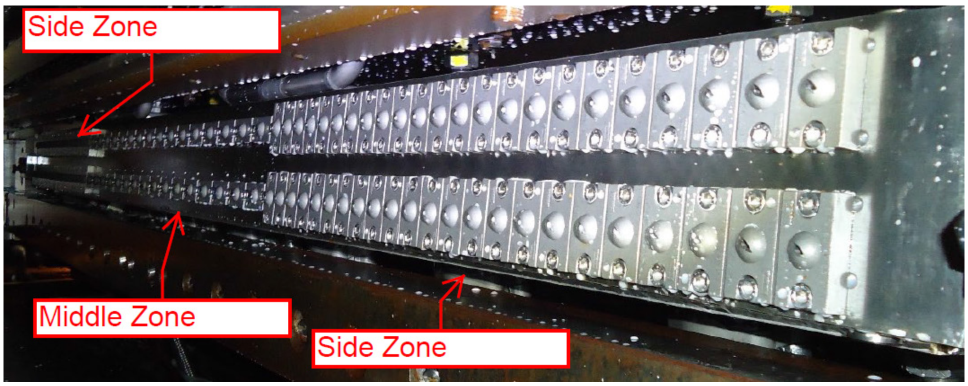

Fig. 1 – Traditional Cooling Spray Header

Typically, if an operator wanted to convert, for example, the middle zone from a 52 mm nozzle spacing to a 26 mm nozzle spacing, either the old spray header would have to be removed and a completely new header would be installed, or new nozzle plates would be machined with new internal porting. Such endeavors are time-consuming, expensive, and suffer from drawbacks. For example, machined nozzle plates typically include more orthogonal channels due to limitations in the machining process, which lead to pressure losses and more turbulent flow.

In view of these limitations, an improved nozzle assembly is provided that allows for the conversion of a 52 mm zone into a 26 mm zone by using the same inlet to supply coolant to two nozzles instead of one. In particular, the nozzle assembly creates a nozzle of approximately the same height with internal porting to divert coolant flow from one inlet into two paths that feed two nozzles instead of one. The nozzle assembly is formed via additive manufacturing (AM) such that the internal porting has an improved shape and profile (e.g., smoothly curving channels), thereby leading to lower pressure losses and improved laminar flow compared to machined nozzle assemblies. Additive manufacturing may also provide a lower cost alternative for changing cooling pattern compared to existing options. Using nozzle assemblies formed via additive manufacturing may also not require for a flatness control system to be modified.

Referring to the figure below, the improved nozzle assembly includes a nozzle body, an internal cavity with channels, flow straighteners that may be incorporated into some or all of the internal cavity, and nozzle caps. The nozzle caps may be modeled such that they match the 26 mm spacing geometry, and may be adapted to dispense the coolant in various patterns to achieve a desired spray footprint. The final nozzle slit may be added as a finishing operation via more traditional subtractive processes such as CNC machining. This type of finishing operation would produce smooth faces and more precise/sharp angles, which would be beneficial for spray foot development as well as footprint repeatability. Alternatively, if it is found to be more economical, the nozzle caps may be manufactured though traditional subtractive methods and designed to be assembled into the nozzle block, so that the nozzle assembly is printed with smooth, curved internal porting and the nozzle cap is added as a secondary operation. This would also allow the internal finishing (e.g., via sanding/polishing, media blasting, coating, etc.) of the porting, allowing smooth internal walls for improved flow.

The internal channels of the nozzle assembly may divert the incoming coolant flow. The twist angle and/or spray direction of a given nozzle may be controlled during the manufacturing process of the nozzle assembly, which may allow for manipulation of the spray footprint (size, shape, location, etc.) to create a desired spray pattern across a strip being processed. Turbulence in the coolant may be optionally minimized with the flow straighteners, thereby providing a more laminar flow, which may be a necessary condition to create a predictable and/or un-distorted nozzle spray pattern on the roll. As mentioned, the nozzle body and/or internal channels may be formed via additive manufacturing due to the small area that is available for the channels. The geometry of the internal ports may be modified as needed for flow considerations, and may be modeled in a helix type or other configuration to allow a longer channel distance for flow conditioning.

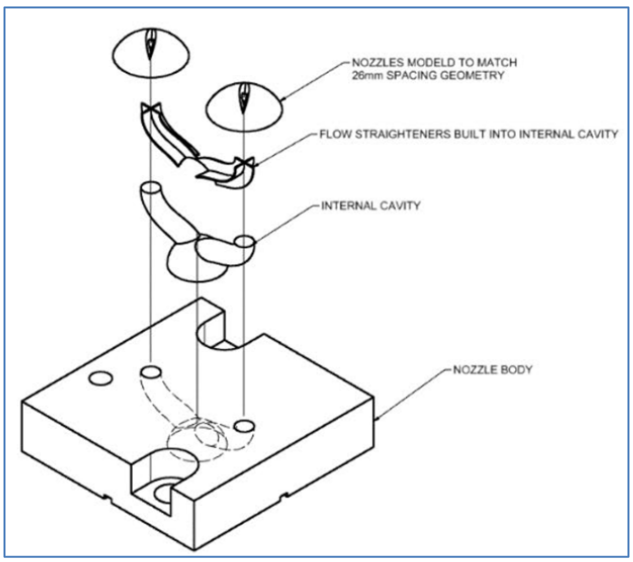

Fig. 2 – Improved Nozzle Assembly

The figure below illustrated the nozzle assembly in an assembled configuration.

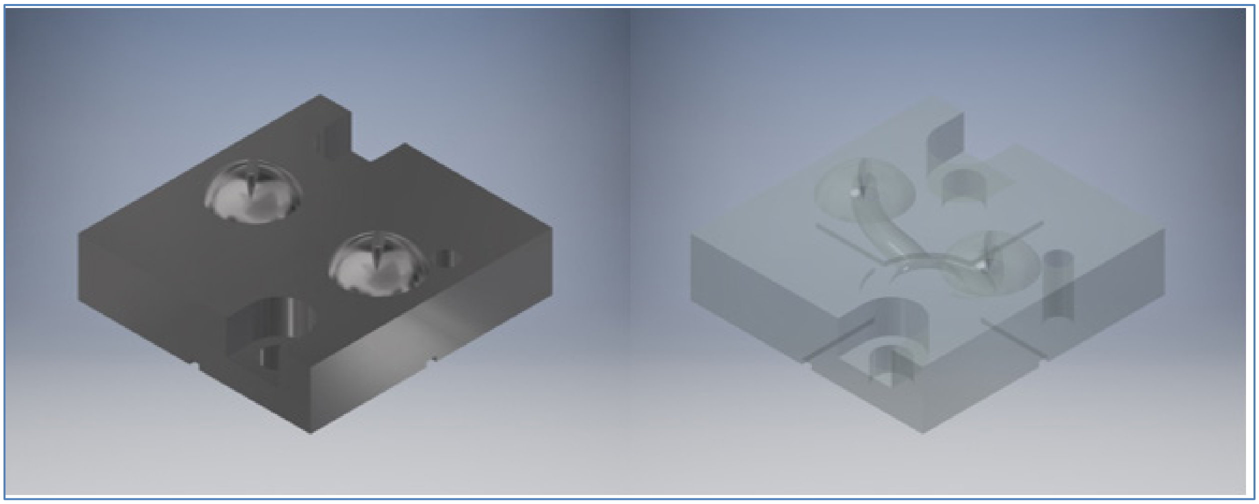

Fig. 3 – Assembled Nozzle Assembly

As illustrated in the figure below, each nozzle assembly includes a single inlet in fluid communication with the header, and the internal channels split the flow in a narrow space and directs the coolant to two outlets / nozzle caps.

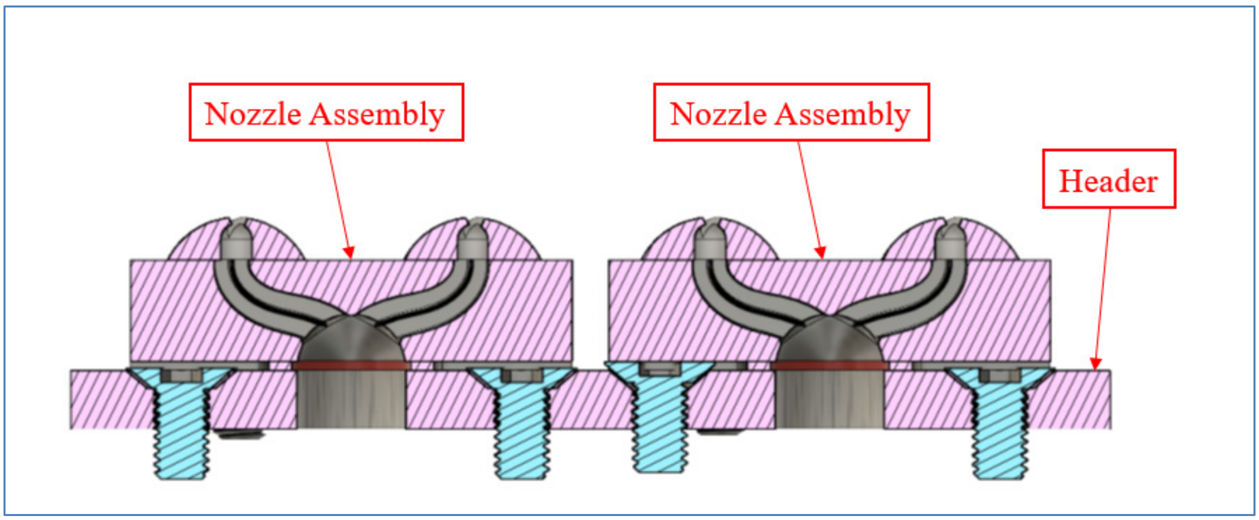

Fig. 3 – Sectional View of Improved Nozzle Assemblies and Header

With this nozzle assembly, an existing cooling spray header may easily have a zone (e.g., the middle zone) changed from one nozzle spacing (e.g., 52 mm) to a different nozzle spacing (e.g., 26 mm). The improved nozzle assemblies occupy the same amount of space as the configuration with the 52 mm spacing and do not require a completely new cooling spray header to be utilized. The improved nozzle assemblies may allow for better control of cooling, which may affect the ability to control strip flatness of a strip being rolled and/or reduce the likelihood of product surface imperfections. In certain aspects, the improved nozzle assemblies will allow for a higher quality final product, which may lead to less scrap and/or improved recovery. The improved nozzle design may also lead to fewer nozzle clogs and/or failures, which may decrease downtime due to nozzle issues that would need to be corrected.

This nozzle assembly may be manufactured using metal or resin/polymer via various AM manufacturing technologies. Polymer resins manufactured through SLA can provide a unique blend of chemical resistance, wear resistance / toughness as well as low cost. Metal nozzle assemblies could also be manufactured through DMLS (Direct Metal Laser Sintering) & metal binder jet + sintering for example to achieve the desired design features outlined above using readily available powers - stainless steel 17-4 PH & 316L for example - which may be used in either process. Additional considerations to the design may be necessary depending on the manufacturing method and build orientation due to the need to account for support structures, warping or material trapping for example.

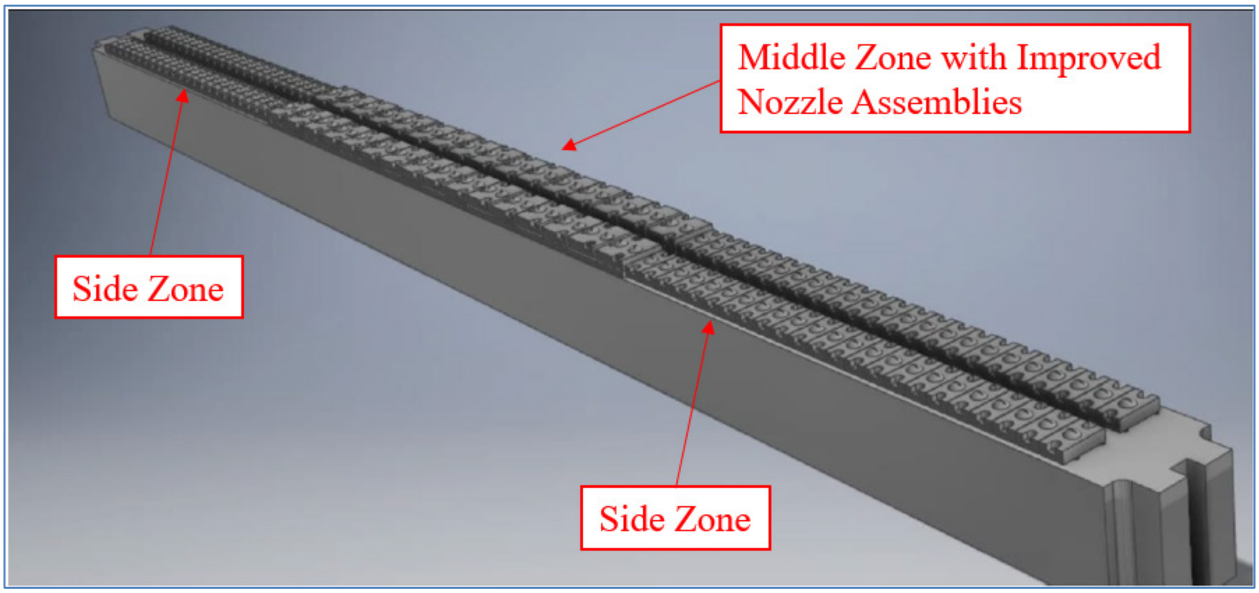

Fig. 4 – Cooling Spray Header with Middle Zone having Improved Nozzle Assemblies