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HYDRODYNAMICS OF LIQUID FLOW IN NOZZLES

This article introduces the classification and characteristics of common nozzles and describes their applications and research value across different industries and fields. It details the world's leading patents for centrifugal nozzles, electromagnetic nozzles, coaxial nozzles, and vortex nozzles, explaining the operating principles and innovations of various inventions while analyzing their potential for improvement [1–4]. Additionally, the article covers the theoretical foundations of the fluid dynamics characteristics of liquid flow in nozzles, including CFD simulation software, principles of fluid mechanics, components of fluid dynamics, numerical simulation methods, and nozzle principles.

The article simulates and analyzes four different centrifugal nozzles: CLN (centrifugal long nozzle), CLNH (centrifugal long nozzle with hole), CShN (centrifugal short nozzle), and CShNH (centrifugal short nozzle with hole) by controlling the water inlet speed. It calculates the nozzle outlet speed using the Bernoulli equation. The water flow speed and tangential speed within the nozzles are actively analyzed, and the pressure loss for each nozzle is calculated. Experiments are also conducted on the four nozzles to verify the accuracy of the simulations. By controlling the water inlet flow for the different nozzles and measuring the inlet and outlet cross-sectional areas, the water inlet and outlet speeds can be determined, allowing for the calculation of pressure loss. By maintaining the same water inlet flow rate for the different nozzles, the atomization spray angles of the four nozzles are compared and measured using a camera, leading to final conclusions. Using Bernoulli's equation define hydraulic pressure of nozzles (1):

$$\Delta p = k \cdot \frac{\rho \cdot v^2}{2} \qquad (1)$$

где k – resistance coefficient; ρ – density of the liquid, kg/m³; v – flow velocity, m/s.

In Figure 1, you can see the variation in hydraulic pressure of the nozzles.

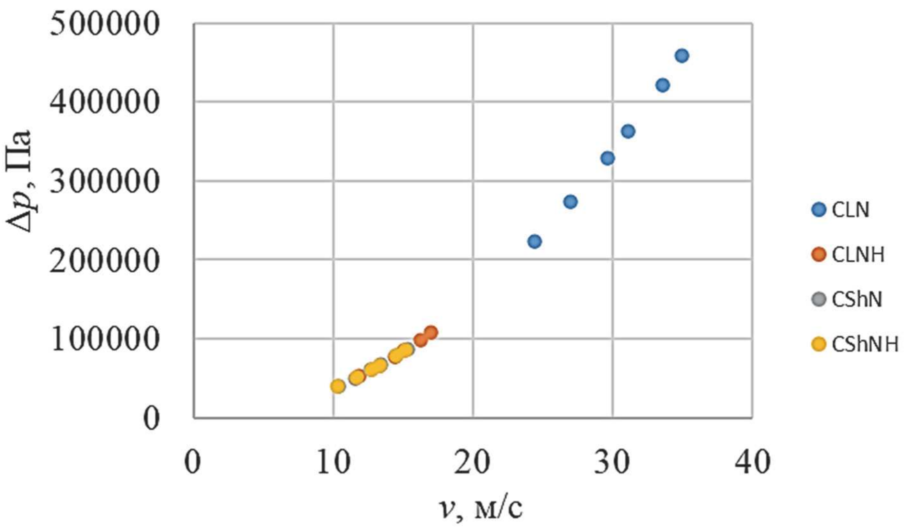

Figure 1 – Hydraulic pressure of the nozzles

Through simulation and active analysis (fig. 1, fig 2), we found that when the water flow rate, nozzle cross-sectional area, and flow rate of the four nozzles are the same at the input and output ends, the water pressure of the CLN is the highest. In comparison with the CLNH, we observed that the hole in the center of the CLNH disperses part of the water pressure, which reduces the spray angle and weakens the atomization capability of the nozzle.

In Figure 2, you can see the variation in water speed within the nozzle.

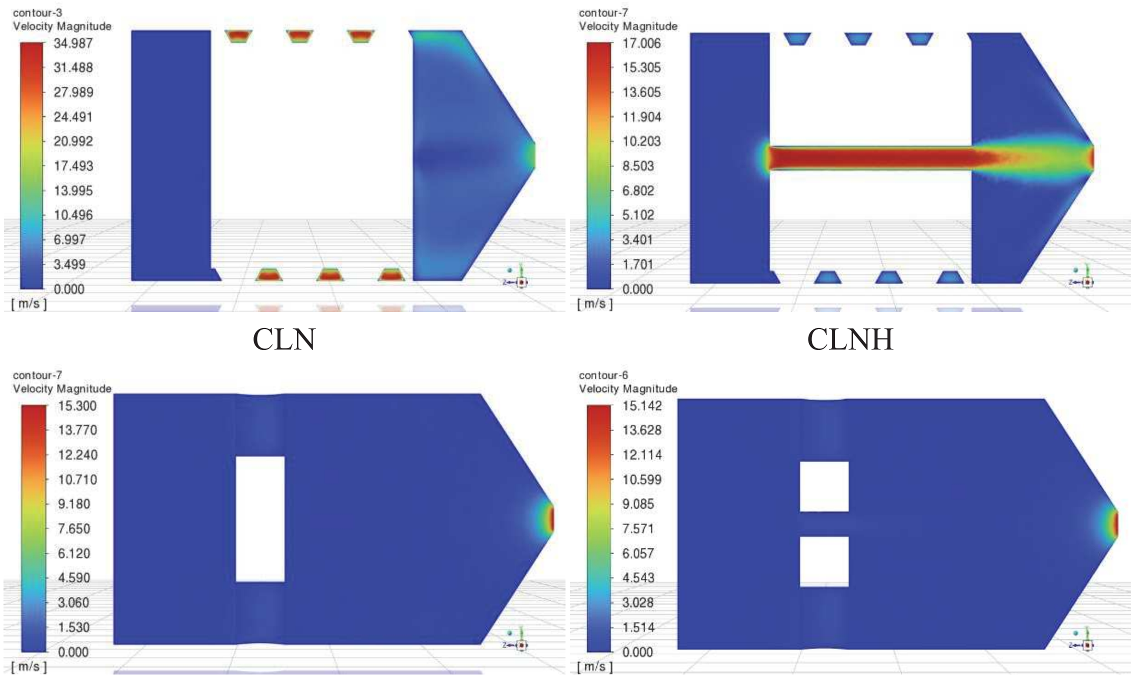

Figure 2 – Water speed in the nozzle

In our analysis of the CShN and CShNH nozzle types, we observed that the presence of a central hole has a minimal impact on the performance of the short nozzle configuration. This finding suggests that the central hole's influence is intricately linked to the specific geometry of the CLN nozzle design.

The CLN nozzle features tangential channels that are inclined at a 60° angle relative to the nozzle's central axis. This unique angle enhances the flow dynamics within the nozzle. The introduction of a central hole provides a pathway that reduces the resistance encountered by the water as it travels through these tangential channels. Specifically, the central hole decreases the resistance coefficients associated with the flow, which in turn leads to a reduction in overall water consumption.

In the case of the CShN nozzle, we found that the water flow rate remains nearly constant despite the presence of the central hole. This stability in flow rate can be attributed to the relatively large cross-sectional area of the channels within the CShN configuration. The ample channel area allows for efficient flow, mitigating any potential reductions in flow that might arise from the central hole.

In Figure 3, you can see the spraying of water from the nozzles.

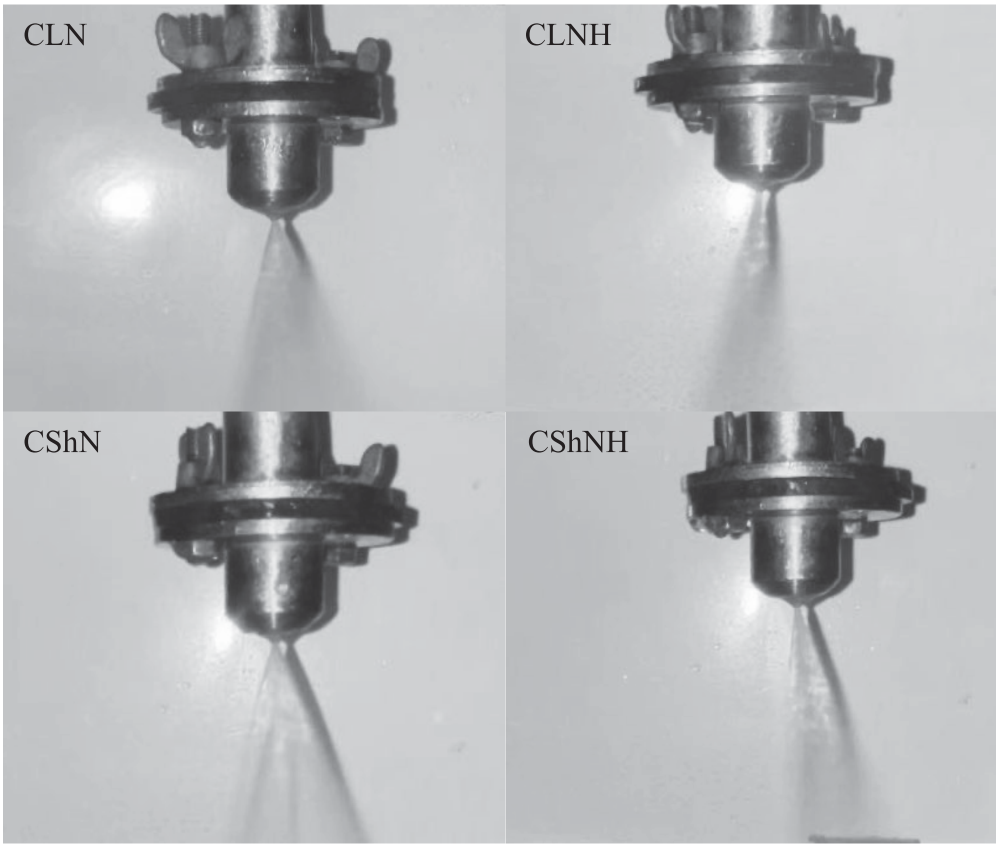

Figure 3 – Spraying of water from nozzles

We conducted laboratory (fig. 3) experiments for four different nozzles. We compared and found through observation that CLN and CShN have the largest spray angle than CLNH and CShNH, due to the high velocity in the tangentially directed channels. The decrease in the angle may be due to the fact that the main liquid flow passes through the central hole and reduces the swirl of the liquid by reducing the flow rate in the tangential channels of the nozzles. The experimental results partially coincide with the simulation results.

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DESIGN AND ANALYSIS OF SPHERICAL PACKING WITH HEMISPHERICAL DEPRESSIONS FOR ENHANCED MASS TRANSFER

Mass transfer apparatuses with moving packing are an important class of equipment widely used in various industries such as chemical, petrochemical and food. These apparatuses are designed to perform mass transfer processes, including rectification, absorption, desorption and extraction. They play an important role in the effective separation and purification of substances [1].

In such apparatuses, the mass transfer process occurs between two phases (gas-liquid, liquid-liquid) with a developed interphase surface. The main feature is the presence of a moving packing, which helps to intensify mass