Optimum viscous flow in pressure-swirl atomizers

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Due to their simple configuration and reliable operation, pressure-swirl atomizers are widely used in applications such as combustion, painting, humidification, and sprinkling. The liquid is swirled by entering into the atomizer tangentially and its surface area is increased as discharges in a large spray angle. Understanding the effects of nozzle geometry and inlet flow condition on the discharge coefficient and spray angle is very important in nozzle design. To this end, the flow field inside a pressure-swirl atomizer has been studied theoretically. The main body of the liquid is taken to be moving in circles round the axis. Within the boundary layer, containing transverse and longitudinal velocity components, the retarded liquid is slowed down by viscosity and driven towards the exit orifice by pressure gradient. The swirling motion of liquid creates a low pressure zone near the nozzle axis and leads to the formation of a helical air-core. Through studying the growth of the boundary layer from nozzle entry to the orifice exit, the portions of the outflow exits the orifice from boundary layer current and also from the main body of the swirling liquid are specified. For a given range of pressure drop values, the optimum nozzle geometry and liquid flow rate are predicted. Additionally, the reason of increasing the flow by increasing liquid viscosity or decreasing orifice diameter is explained. A series of experiments and numerical modeling have also been carried out to support the theoretical results.