ABSTRACT

The inherent and widespread impact of swirl spray pressure nozzle in the field of industry has motivated to envisage the present work to throw light on some interesting specific aspects of swirl nozzles. The present work comprises five chapters. The Chapter 1 discusses the practical importance of the problem highlighting the state of art and scope of the present work. Chapters 2, 3 and 4 of the thesis address the following three specific problems of swirl nozzles.

- **Initiation of Air Core in Hollow Cone Swirl Nozzles**
- **Influences of Nozzle Flow and Nozzle Geometry on the Shape and Size of a Fully Developed Air Core in Hollow Cone Swirl Nozzles**
- **The Coefficient of Discharge and the Spray Cone Angle of a Solid Cone Swirl Nozzle**

The Chapter 5 provides the conclusion of the present work and the scope of future work.

The Chapter 2 addresses the phenomenon of initiation of air core in conical and cylindrical hollow cone swirl nozzles from experimental investigations. The two limiting values of Reynolds number (Re) at inlet to the nozzle have been recognized as the criteria of air core formation in the nozzle. Below the lower one, the formation of air core does not take place in course of flow through the nozzle, while above the upper one, there appears always a fully developed central air core within the nozzle.

It has been observed that in case of a conical swirl nozzle, the pertinent dimensionless geometrical parameters of the nozzle which influence the values of the two limiting Reynolds numbers (Re_{L1} and Re_{L2}) are (i) the ratio of orifice diameter to swirl chamber diameter (D_o/D_s) and (ii) the ratio of tangential entry port diameter to swirl chamber diameter (D_p/D_s). The values of Re_{L1} and Re_{L2} decrease with an increase in the value of the ratio of D_o/D_s and a decrease in the value of the ratio of D_p/D_s.

In case of a cylindrical nozzle, the only influencing pertinent dimensionless geometrical parameter of the nozzle on the values of Re_{L1} and Re_{L2} is the ratio of tangential entry port diameter to swirl chamber diameter (D_p/D). The values of Re_{L1} and Re_{L2} decrease with a decrease in the value of the ratio of D_p/D.

The Chapter 3 describes theoretical and experimental studies on the influences of nozzle flow and nozzle geometry on the shape and size of a fully developed air core in hollow cone swirl nozzles. The theoretical study is based on the numerical solution of conservation equations for mass and momentum along with the volume fraction of the liquid phase. Interface capturing method has been adopted in the numerical simulation of free surface flow in the nozzle. Experiments have been carried out with a number of nozzles fabricated by perspex material. The air core diameter has been measured from the photographs taken by a camera from outside the nozzle.

It has been observed that the shape of a fully developed air core in a conical swirl nozzle is cylindrical with a considerable bulging at the adjoining section of swirl chamber with the orifice, while the air core is uniform throughout in case of a conical nozzle without having a finite length of the orifice.

The values of air core diameter in the swirl chamber (da_1) and in the orifice (da_2) of a conical nozzle increase sharply with an increase in inlet Reynolds number (Re) at its lower range but become almost independent of Re at its higher range. Both da_1 and da_2 increase with an increase in the value of D_o/D_s or α and with a decrease in the value of D_p/D_s or L_o/D_s. The proportional increase in air core diameter (either da_1 or da_2) is more than that in the value of D_o/D_s. The increase in da_1 is more than that in da_2 with either an increase in the value of D_o/D_s or a decrease in the value of D_p/D_s.

The air core in a cylindrical nozzle is found to be helical in shape with an elliptical cross section.

The Chapter 4 presents theoretical and experimental investigations of the coefficient of discharge and the spray cone angle of a solid cone swirl nozzle. The theoretical investigation is based on the numerical computation of flow within the nozzle by solving the conservation equations of mass and momentum. The standard k-ε model has been adopted for turbulence in the flow. The values of the coefficient of discharge (C_d) and the spray cone angle (ψ) have been evaluated from the radial distributions of velocity components of liquid flow at the nozzle exit. Experiments have been carried out to determine C_d and ψ of a solid cone swirl nozzle at different operating conditions to corroborate the results obtained from numerical computations in identical situations.

It has been observed that the coefficient of discharge (C_d) and the spray cone angle (ψ) are almost uninfluenced by the Reynolds number (Re) of flow at inlet to the nozzle. An increase in inlet swirl number (S) increases the value of ψ. The influence of swirl number (S) on ψ is profound in the entire range of S from 0.6 to 3.0 as studied in the present work. The coefficient of discharge (C_d) undergoes a marginal decrease (of about 6%) with an increase in S from 0.6 to 1.2, while the decrease in C_d is considerable (of about 20%) when S is increased from 1.2 to 3.0.

An increase in the value of flow ratio (q_r) increases the value of C_d and decreases the value of ψ. However, the influence of q_r on C_d is prominent at lower values of diameter ratio (D_2/D_1). The value of C_d increases with a decrease in the value of the ratio of D_2/D_1 mainly in the range of higher q_r and for values of D_2/D_1 less than 0.17. The spray cone angle (ψ), on the other hand, is almost uninfluenced for all values of D_2/D_1 below 0.38, while ψ

increases when D_2/D_1 is increased beyond 0.38. The increase in ψ is more prominent in the lower range of flow ratio (q_r).

It has been recognized, from a fair agreement between the numerical and experimental results, that the use of standard k-M model of turbulence for a swirling flow in the nozzle is adequate for accurate predictions of nozzle performance parameters like, C_d and ψ.

The Chapter 5 provides the conclusion of the present work along with the scope of further work.