Influence of Medium Viscosity on Atomization Characteristics of Pressure Swirl Nozzle

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Abstract The influence of medium viscosity on discharge coefficient, Sauter Mean Diameter (SMD), droplet velocity, spray cone angle of the nozzle is experimentally investigated by Particle Dynamics Analysis system and High-speed Photography system. Water-glycerol mixture with different mass fractions is used to simulate media with series of viscosities. It is found that the development of axial speed distribution of the spray cone is from the "double peak distribution" to "triple peak distribution", and finally turning into "single peak distribution". With the increasing of the viscosity, the axial speed is increasing and the fully developed distance gets longer. Also, the spray cone is divided into three regions according to its spray SMD.
Keywords: Pressure swirl nozzle, Medium viscosity, PDA system, Speed distribution

1 Introduction

The aero engine is the heart of the aircraft, which is the decisive factor of the victory of the modern warfare and the significant reflection of the national power. The fuel atomizer is the key component of the combustion chamber of the aero engine and its atomization characteristics directly determine the combustion performance and pollutant emission of the aero engine. Pressure swirl nozzles are widely used in aero engines, gas turbines and other power equipment due to its geometrical simplicity, good atomization performance and low cost. Medium viscosity is one of the most important factors for the atomization of the pressure swirl nozzle. Studying the mechanism deeply can not only improve the atomization quality of the nozzle under different working conditions, but also provide a reliable theory for finding the substitute of the fossil fuel.

2 Experimental Design

Photographic and schematic diagram of experimental apparatus used in this study are shown in Fig. 1. It consists of an experimental nozzle, a dynamic particle analyzer, a high-speed camera system, and a supply system. The experimental nozzle structure is shown in Fig. 2.

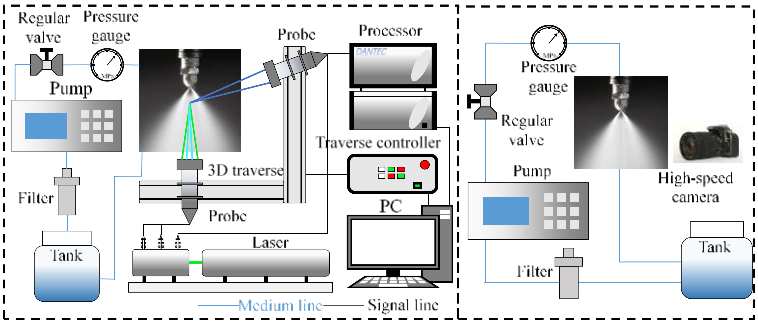
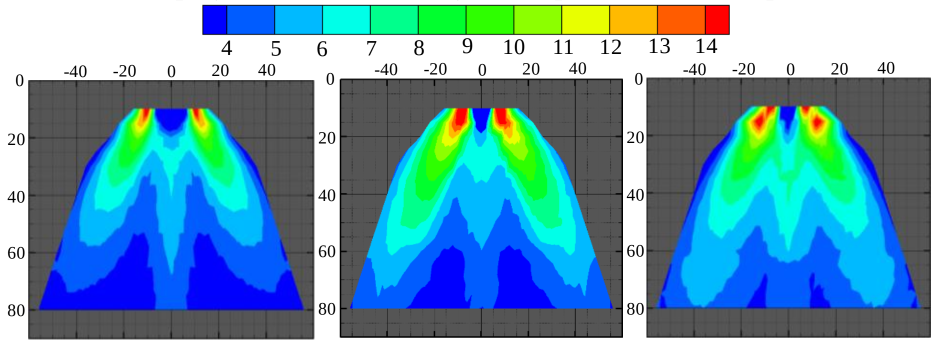


Fig. 1 Schematic diagram of experimental device

Fig. 2 Structure of experimental nozzle

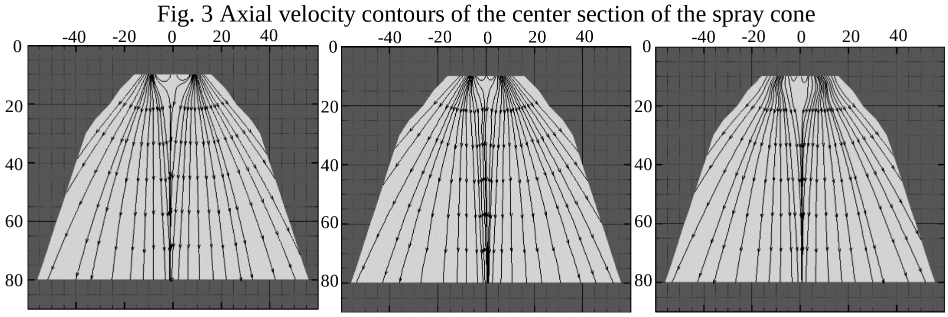
3 Results and Discussion

In order to study the axial and radial distribution of the droplet axial, the measured points are interpolated using Tecplot software to obtain the axial velocity contours and streamline diagram of the central section of the spray cone at different viscosities shown in Fig. 3 and Fig. 4. The axial velocity at the section of 10 mm to 20 mm below the nozzle shows obviously "double peak distribution" which means high velocity on both sides but low in the middle (Fig. 3). The velocity gradient of small droplets breaking up from the liquid film is high, due to the shearing action with the central air core, and the velocity decays faster. Velocity of the middle part is low because the swirling effect of the nozzle results in a negative pressure zone formed at the axis. The negative pressure zone will suck the internal droplets, leading to the velocity drop, and some small droplets even flows back (Fig 4). As the viscosity increases, the swirling effect gradually decreases, and the area of the low velocity zone becomes smaller. At 20 mm to 30 mm below the nozzle, droplets are gradually slowed down by the ambient air. When the circumferential velocity of droplets around the air core is not enough to support the central negative pressure, the air core will collapse and droplets near the air core will move to the axis, which forms a "densest spray region" at the axis of the spray cone[1]. The ambient air enters the spray cone to compensate the corresponding volume, and the incoming air is on both sides of the "densest spray region" and causes the medium to slow down (Fig. 3) . The radial distribution of the axial velocity gradually changes from "double peak distribution" to "triple peak distribution" (Fig. 3), which is consistent with the conclusion of literature [1, 2]. As shown in Fig. 3-a), the velocity gradient along the expansion direction of the liquid film is high, but in "densest spray region" is low. The spray cone eventually develops to a "single peak distribution". As the viscosity increases, the spray SMD and the axial velocity becomes larger, resulting in the spray distance increasing. Distance that the spray cone reaches a fully development also rises up.



a) Medium A   b) Medium B   c) Medium C

Fig. 3 Axial velocity contours of the center section of the spray cone



a) Medium A   b) Medium B   c) Medium C

Fig. 4 Streamline diagram of the center of spray cone

4 Conclusions

Axial velocity distribution of spray cone changes from “double peak distribution”, “triple peak distribution” to “single peak distribution”. As the medium viscosity rises up, the area of the negative pressure zone below the nozzle gradually becomes small, while the spray distance and the distance that the spray cone becomes fully developed gets longer.

5 References

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