Study on the equal pressure distributed hydrokinetics of the supplying ink for continuous inkjet printing system

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Abstract

Supplying uniform pressure ink in continuous inkjet printing system is the key factor for forming uniform and constant speed ink droplets, it is related to the final imaging effects, this research has seldom been reported in these years. This paper studied on the hydrokinetics and uniform distributed mechanics of supplying ink pressure for the continuous inkjet printing system based on the theoretical calculation, CFD(Computational Fluid Dynamics) and the advanced testing equipment. According to the analysis of laminar flow characteristics and the other jetting flow dynamics factors of the ink, a new type of equipment for supplying ink was designed in this paper, including the structure of the transition pipe and nozzle. The shape of the equipment is rectangular, where the flow section is gradually tapered. This supplying ink equipment can make the ink droplets distribute under the equal pressure on the cross direction. This study educed the optimally hydrokinetics parameters for the continuous inkjet printing. The experiments showed that this new supplying ink equipment could make the ink droplets distribute under the equal pressure and uniform velocity on the cross direction, so it greatly improved the imaging effects for the continuous inkjet printing system.

1 Introduction

Inkjet imaging printing technology is a type of replication technology, which uses the nozzle to eject the ink on the substrates, and generates the needed color and density through the deposition of the slight droplets on the substrates, then makes the ink form the stable image[1]. Inkjet imaging is a type of non-contact printing, it has a wide range of media, not only realizes high resolution printing, but also it can realize intelligent operation. Inkjet imaging printing technology has developed in recent years dependent on the fast, flexible and a wide applicable range characters, it has become the mainstream of digital printing technology[2] . In the inkjet imaging printing technology, a key issue is need to resolve the problems of the ink breakup and droplets control, otherwise Inkjet can not produce satisfactory results. Inkjet and droplets forming although finish in a very little space, related to the areas of fluid dynamics is quite complex. Foreign researchers have done some more detailed study on the fluid dynamics of the inkjet-droplets forming-droplets breakup over past decades. In 1962,Viilu determined the minimum Reynolds number in the instability work state of the free jet during the inkjet tests; Ptiinney studied on the jet fracture problem in turbulent gas in 1973,and presented ink could not maintain continuous jet if jet ink moved in high speed and be interfered by the turbulent gas[3]. According to the above studies, ink laminar jet was the basic conditions for ensuring continuous inkjet based on the continuity equation and the movement rules of the viscous fluid[4] [5]. As mentioned above, according to a great deal of the research information, the study of the ink droplets continuous jet–forming-imaging for inkjet imaging printing technology is concentrated in the trajectory when ink droplets move in the electric field and fluid dynamics state after ink droplets leave the nozzle[6],but few people have studied on the key ink droplets forming technology with the shape of the supplying ink equipment, especially the fluid dynamics analysis when ink(including recycling ink) flow in the supplying ink equipment, but not flow into the nozzle. According to the laminar flow fluid dynamics principles of the viscous fluid, when ink jet, supplying uniform pressure ink in continuous inkjet printing system is the key factor for forming uniform and constant speed ink droplets, it is related to the final imaging effects. Furthermore, uniform fluid pressure will minimize nozzle blockage situations, it has important practical significance for the large format inkjet imaging printing system.

2 The structural design of the pressure automatic adjustment equipment for supplying ink

2.1 The fluid dynamics analysis of the uniform pressure

According to the principles of the fluid dynamics and Bernoulli's equation, when some part of ink flow into branch nozzle, if the section size of the main pipeline doesn't change, the hydrostatic head in the main pipeline will increase because of the flow and velocity head reduction, this is the pressure recovery phenomenon. So in order to make the ink gain uniform pressure and velocity distribution in each nozzle, the section size of the main pipeline should be corresponding reduction, in this way the fluid hydrostatic head will not change, this is especially important to the large format inkjet printer. This paper studied on the structure size of the pressure automatic adjustment equipment for supplying ink based on the Bernoulli's equation (detailed derivation is seen in the reference [7]).The structure of the supplying ink pipeline was designed to the rectangular, where the flow section was gradually tapered and the bottom was parabolic based on the theoretical calculation and CFD.

2.2 The structural size calculation of the supplying ink equipment

According to the Bernoulli's equation:

$$\frac{A}{A_0} = Ke^{\frac{fx}{8R}} \tag{1}$$

Where A is the sectional area at x point(m^2);A_0 is the sectional area at ink inlet point(m^2);K is the ratio of section flux to the inlet flux at x point; e is the natural logarithm; f is the friction coefficient, f=0.015; R is the Hydraulic radius(m) , and $R = BH/2(B+H)$.

where B is the width of the rectangular section and H is the height of the rectangular section(m).The width of the rectangular section is equal in design, thus so long as determine the A_0, the section weight at the different points can be calculated based on equation (1).If the x value is smaller then the accuracy is higher, usually the values of the A_0 and x is determined based on the difficulty level of the design and processing. The final designed schematic is seen figure 1 and figure 2.

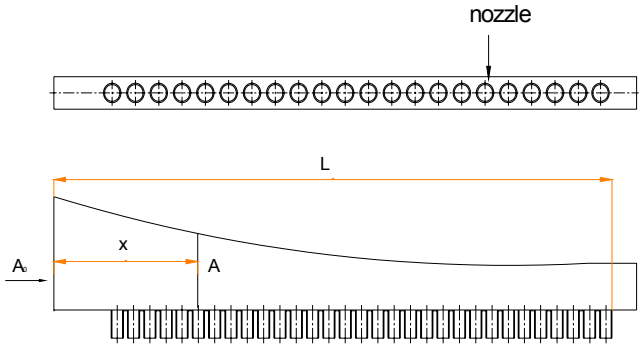

***Figure 1**. the structural design of the supplying ink equipment*

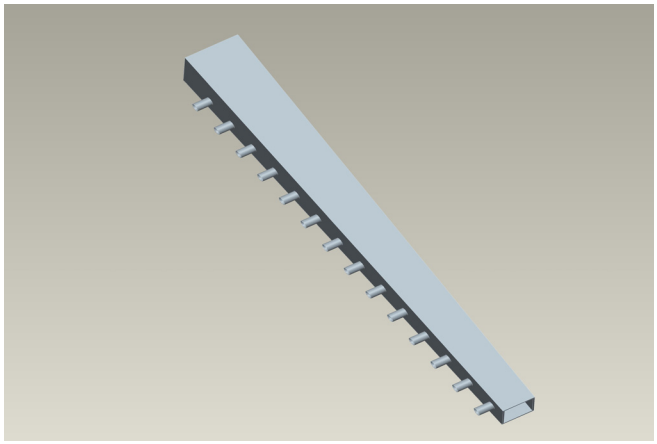

***Figure 2**. the external structure of supplying ink equipment*

3 The computer simulation of the ink flowing in the pressure automatic adjustment equipment

3.1 The software and mathematical model of the computer simulation

The flow patterns of the ink flowing in the pressure automatic adjustment equipment were simulated based on the software FLUENT6.1.22 in this paper. The FLUENT software includes many optimized physical model, such as non-Newtonian fluid laminar flow models and turbulent flow models, each model has its numerical solution method for the corresponding physical flow characteristic. In the FLUENT software, as long as given by the physical properties of the fluid simulation, mathematical models, algorithms and the corresponding initial conditions, the simulation software will simulate the flow patterns of the fluid, furthermore, the numerical results are shown by the graphical visualization[8] . According to the related literature[3] ,the computer simulation of the ink flowing used the laminar flow model and finite-difference discretization algorithm, detailed derivation is seen in the reference [9]and[10].

3.2 Computer simulation results

Seen from the below figures, this supplying ink equipment could make the ink gain uniform pressure and velocity distribution in each nozzle automatically, it was important to the inkjet imaging and would minimize nozzle blockage situations. But the velocity and pressure produced the significant change in the end of the supplying ink equipment based on the figure 3 and figure 4.This was because the flow section wasn't gradually tapered in the end of the equipment.

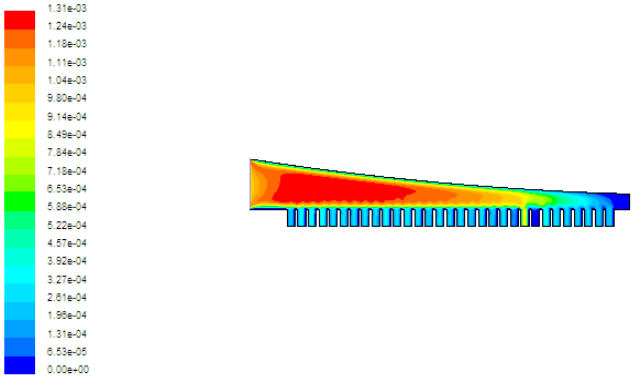

***Figure 3**. the speed contour of ink flow in supply ink equipment(m/s)*

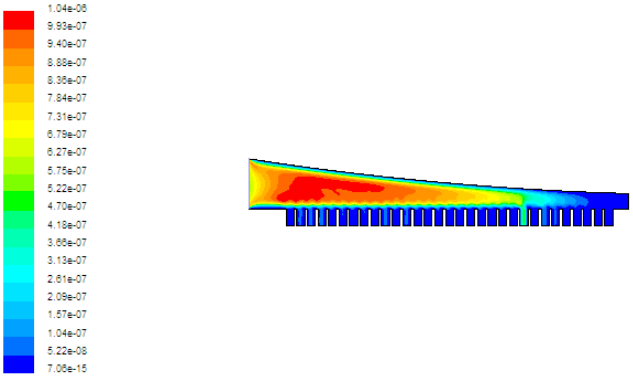

***Figure 4**. the pressure contour of ink flow in supply ink equipment(Pa)*

4 The experimental results of the ink flowing in the uniform pressure automatic adjustment equipment

According to the results of the theoretical calculation and simulation, we carried out the research about the ink flowing in the uniform pressure automatic adjustment equipment, and measured the ink velocity amplitude jetting from the nozzle by Sensorline laser velometer, the results were shown in figure 5.

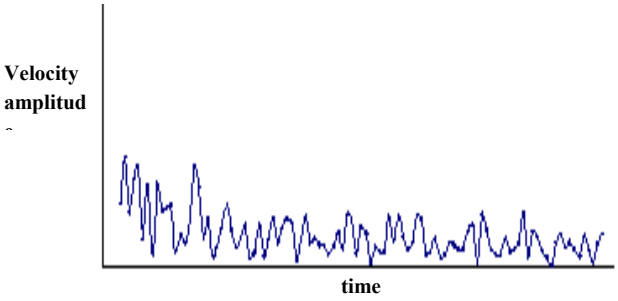

***Figure 5**. the velocity amplitude of the inkjet from the nozzle*

The change of the velocity amplitude for inkjet from the nozzle was small, furthermore the velocity change of the jet point was the same on the cross direction. It also proved that this new supplying ink equipment could make the ink droplets distribute under the equal pressure on the cross direction and improved the imaging effects for the continuous inkjet printing system.

5 Conclusions

This paper studied on the hydrokinetics and uniform distributed mechanics of supplying ink pressure for the continuous inkjet printing system based on the theoretical calculation (Bernoulli's equation), CFD(Computational Fluid Dynamics) and the experiment, and designed a new type of equipment which was rectangular, where the flow section was gradually tapered and the bottom was parabolic structure. The results of the simulation and experiment showed that this new supplying ink equipment could make the ink droplets distribute under the equal pressure and uniform velocity on the cross direction, the velocity amplitude was small, the inkjet droplets were stable, uniform fluid pressure will minimize nozzle blockage situations , it has important practical significance for the large format inkjet imaging printing system and it greatly improved the imaging effects for the continuous inkjet printing system.

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