Influence of Nozzle Control Parameters on the Drop State of UV-curable Ink-jet Ink

XiaoYang; Beiqing Huang;Xianfu Wei;Zhenxing Zhang Beijing Institute of Graphic Communication, Beijing, China

Abstract

The drop state of the ink-jet ink is an important factor that influences the ink-jet imaging quality,nozzle characteristics and parameters have a great influence on the final drop state.In order to meet the requirement of printing quality，prepare UV ink-jet ink is appropriate for XAAR ,and printing under different voltage and ignition frequency,observe and analysis the drop state under different ink-jet condition .The result shows that it's existed a large differences of the drop state including drop speed,drop volume and drop tail length when the UV ink-jet inks under different voltage and ignition frequency,there is a certain relationship between control parameters of the nozzle and the ink's drops state.

Introduction

UV ink-jet ink is a kind of reactive digital printing ink，can realize the instantaneous curing，zero VOC,it's a recognized environmental printing ink currently.Ink-jet printing adopt droplet spray technology,it's a non-contact printing without printing plate and pressure, it could theoretically spray various material of droplet to any printing materials to form the required patterns or product.For piezoelectric ink-jet, the spraying voltage and frequency have certain influence to ink-jet ink drop state, drop state of UV ink-jet ink will affect the final print quality directly[1],so researching the drop state under different voltage and frequency is important for guiding the production.

Experiment

Experimental Material.

Pigment:Phthalocyanine blue(Ciba); Prepolymer:Polyester acrylic resin(Viajet100,Viajet400,Cytec);Monomer:EOEOEA,

HDDA,TMPTA(Tian Jiao);Initiator:IHT-PI ITX 、 IHT-PI 907;Active amine:EHA.

Experimental Supplies and Equipment.

Model JJ-I mechanical stirrer;Model 81-2 constant temperature magnetic stirrer;Multipurpose nanostructured grinding machine-BUHLER;Model Ⅱ A-1501 Drops Observatory;Sheng De SD6680 Ink-jet Printer;

Sample Preparation.

Mixed monomer and wetting dispersants together ,scattered 30min with magnetic stirrer,and then,scattered mixture with a mechanical stirrer after adding pigment and prepolymer to mixture.At last,grinding mixture 30min get UV ink-jet ink paste with multi-purpose nanostructured grinding machine- BUHLER .

Mix quantitative monomers and dilute resin in a certain proportion, join photoinitiator and then heating and dissolving the mixture, add ink color paste and stir two hours, get UV-curable inkjet ink.

Text Method.

Drops state is observed through drops observatory which installs Xaar382 nozzle under different voltage and different ignition frequency,evaluate the drop states who out of the nozzle in 130μs including velocity of drops、drop volume、tail length and roundness.

Experimental Results and Analysis

Piezoelectric Ink-jet Printing Theory and The Influence of UV Ink-jet Ink on Drops state.

Piezoelectric Ink-jet Printing Theory.

All of the piezoelectric ink jet system are equipped with transducer on the nozzles who are loaded with ink.The piezoelectric transducer is controlled by the input digital signal,so as to control the ink jetting.For piezoelectric ink-jet printing, the drop is sprayed out through the volume changes of the piezoelectric ceramic transducer (PZT). Give PZT single pulsed voltage as Fig.1.

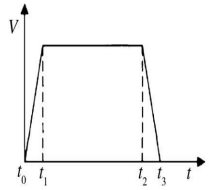


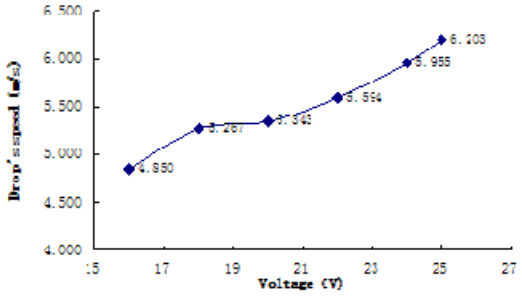
Fig.1 *the voltage to the PZT*

During t_0-t_1, the volume of PZT will quickly become smaller and the nozzle chamber volume will become bigger accordingly, the pressure to the liquid inside the nozzle chamber will become to a negative value and the droplet necking happens. During t_1-t_2, the PZT volume and nozzle chamber volume will not change and the pressure will not change. During t_2-t_3, PZT will back to the initial condition, and give the liquid a positive pressure, as the result of the instantaneous pressure enough to overcome the liquid surface tension, liquid will be sprayed out of the nozzle[2].

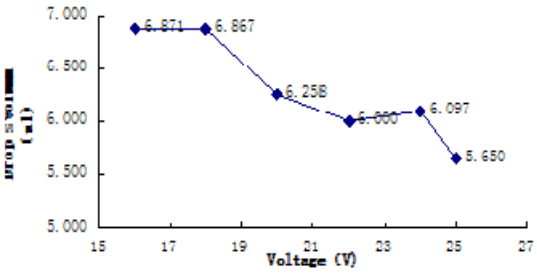
Piezoelectric ink-jet technology control drop's spraying through the changes of voltage,it's a relatively gentle physical process,and able to precisely control the size and shape of the ink drops, thus present a better print quality.

The Influence of Voltage to Drop State.

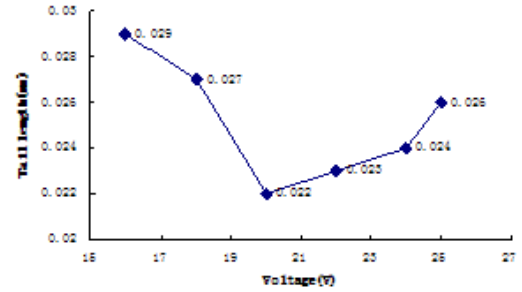
Preparation of UV inkjet ink whose printability matched with the XARR nozzle,give PZT single pulsed voltage in the range of voltage,voltage is set respectively 16V, 18V, 20V, 22V,24V and 25V,observe and measure the drop state under different voltage.the result was shown in Fig 2.



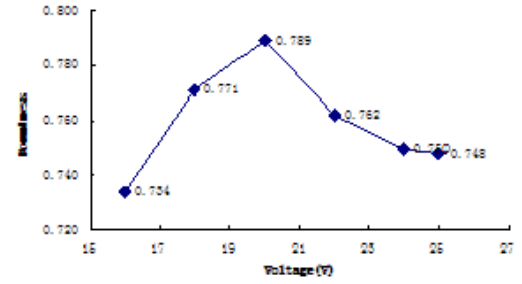
(a) Velocity of drop



(b) Volume of drop



(c) Tail length



(d) The roundness of drop

Fig 2.*UV inkjet inks' droplets status under different voltage*

Fig2-a shows that,with the increase of pulsed voltage,the velocity of drop increases.the result is that the greater the pulse voltage, the greater the deformation of PZT,the positive pressure imposed for drops is bigger corresponding,therefore the acceleration of drops out of the spray orifice was greater, drops speed was greater at the same time.

Fig 2-b shows that,drop's volume decreased as the pulsed voltage increased.it's because of they are both have a certain volume of nozzle's spray hole and the drops who spray out of the nozzle,as the increase of pulse voltage,the speed of drops spray out of nozzle increases,resistance of nozzle wall to ink drops increases too,the force that draw the drop back at necking stage is large, there would be part of the liquid back to the nozzle, cause the final volume decrease.

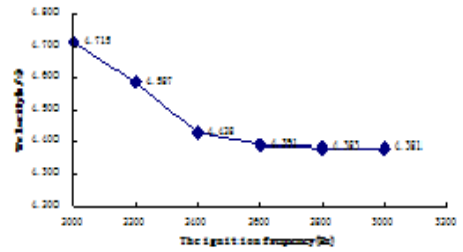
Fig 2-c shows that,when pulsed voltage is less than 20V,drop tail length reduce gradually as the viscosity increased.when pulsed voltage is more than 20V,drop tail length increases gradually.the result is that as the increase of pulse voltage,the speed of drops increases in a certain voltage range,resistance of nozzle wall to ink drops increases too,trailing length of ink droplets is reduced accordingly.When the voltage is too large,pressure on the drops increased,the drop's cohesion force is weak,so as to droplet's trailing length are increased in the process of running.

Fig 2-d shows that,when pulsed voltage is less than 20V,roundness of droplet's rise gradually as the viscosity increased.when pulsed voltage is more than 20V,roundness of droplet's decreases gradually.Due to the roundness of drop is a weigh to measurement round degree of drops, changing trends of drops roundness and the tail length is negatively correlated.So the drops roundness in Fig 2-d have a opposite changing trend with the tail length in Fig 2-c.

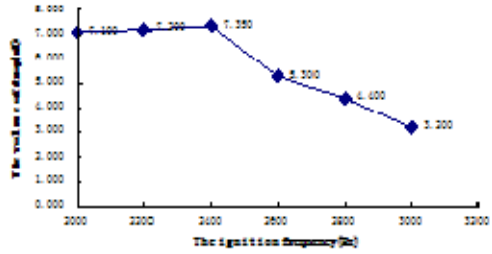
Comprehensive analysis shows that,pulsed voltage have a certain influence on drops state.When the pulsed voltage is 20V,all of the drop velocity, volume,tail length and drop's roundness present a good condition.

The Influence of Ignition Frequency to Drop State.

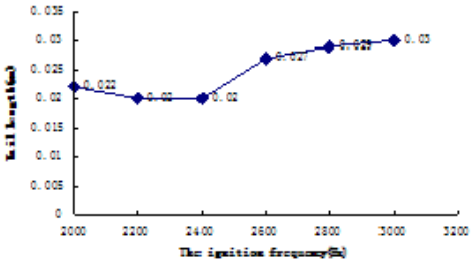
Ignition frequency is the cycle times that repeat the voltage in a second. Give PZT single pulsed voltage as Fig.1, the voltage is set to 20V. Theoretical studies show that if frequency is too big, a pressure wave is not attenuation to a certain level, and then to impose another voltage, the last pressure wave will cause interference to the new voltage, and make the indoor pressure chaos, produce a disorder spray phenomenon [3].Moreover,ignition frequency is too large,drops observatory with CCD camera system are difficult to collected data,so,in this experiment, the frequency is set to 2KHz-3KHz in order to study the influence of frequency to drop state.The test result is shown in Fig 3.



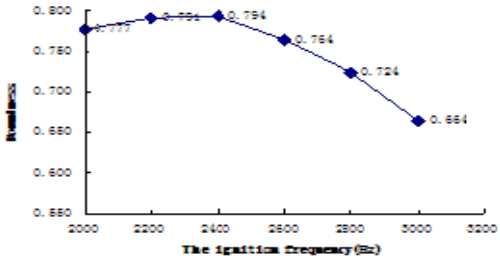
(a) *Velocity of drop*



(b) *Volume of drop*



(c) *Tail length*



(d) *Roundness of drop*

Fig 3 *UV inkjet inks' droplets status under different ignition frequency*

Fig 3-a shows that,when ignition frequency is less than 2400Hz,velocity of drop increased gradually as the ignition frequency increased.when pulsed voltage is more than 2400Hz,velocity of drop decreased gradually.This is because the frequency increases, the time interval of two adjacent pulses becomes short, and the PZT come into the next pulse after back to the initial state quickly, in this time, the volume of the nozzle become large soon and the pressure change into a negative value. And the greater the frequency, the greater the negative pressure is, this pressure will produce a force that draw the drop back, so the speed of the drop reduce.

Fig 3-b shows that,when ignition frequency is less than 2400Hz,volume of drop increased slowly as the ignition frequency increased.when pulsed voltage is more than 2400Hz,volume of drop decreased gradually.The result is that the frequency increases, the time interval of two adjacent pulses becomes short,volume shrinkage of PZT become smaller,the volume of the nozzle become large corresponding.But due to the change of PZT's shrinkage volume is small,so the increase of volume is not significant.when the ignition frequency is too large,negative pressure in Cavity interior is bigger,some residues stayed in the nozzle,so the volume become small gradually.

Fig 3-c and 3-d shows that,along with the rise of ignition frequency, the tail length of drop increases at first,and then decreases.the roundenss of drop increase slowly and then decrease.

The result is that drop's cohesion force is the main factor to influence the tail length,when ignition frequency is less than 2400Hz,velocity of drops out of the spray orifice reduce gradually,acting force between drops and hole wall is less,cause tail length of drop decreases. Due to the change of droplet volume is not big,the time different of ink gather into drop is small, too.So the tail length has a little change.when ignition frequency is more than 2400Hz,the time interval of two adjacent pulses is short, and the PZT come into the next pulse after back to the initial state quickly, in this time, the volume of the nozzle become large soon and the pressure change into a negative value. And the greater the frequency, the greater the negative pressure is,pressure is greater than the ink's cohesion,that allow tail length of drops out of the nozzle or in the running are increased gradually.changing trends of drops roundness and the tail length is negatively correlated,so the drops roundness have a opposite changing trend with the tail length .

Comprehensive analysis shows that,ignition frequency have a great influence on drops state.When ignition frequency is 2400Hz,all of the drop velocity, volume,tail length and drop's roundness present a good condition.

Conclusion

1) Pulsed voltage have a certain influence on drops state,among them,the velocity of drop increases with the voltage increases,drop's volume decrease gradually,trailing length decrease at first,and then decrease.the drops roundness have a opposite changing trend with the tail length.

2) Ignition frequency have a great influence on drops state.the velocity of drop decreases as the ignition frequency increases.trailing length decrease at first,and then decrease.both the drops volume and roundness are increase slowly ,and then decrease with the increase of the ignition frequency.

3) when pulsed voltage is set to 20V and ignition frequency is 2400Hz,all of the drop velocity, volume,tail length and drop's roundness present a good condition.

Reference

[1] Liqin Shi,"Analysis of the Key Factors Influencing on the Ink-Jet Printing,"Jour. Packaging Engineering.4,26 (2005),.

[2] Zhenning Wang,"the numerical simulation of influence in forming process of piezoelectric spray droplet from surface tension and viscosity"Jour. Packaging Engineering.13,31(2010).
[3] Bo Song,"Parameter Analysis of Droplet Ejection of Piezoelectric Ink-jet Printing" Jour. Packaging Engineering.19,32(2011).

Support

This work is supported by the team of Green Printing Materials and Technology Innovation which belongs to the promotion plan of Beijing Municipal Education Commission creative talents "Study of environmental CTP plate and printing ink" (NO.06170113025)

Author Biography

Xiao Yang, born in 1989,a postgraduate comes from Printing and Packaging Engineering college in Beijing Institute of Graphic Communication, China .I'm majoring in printing engineering in my undergraduate period and UV ink-jet ink which is a kind of environmental friendly ink in my postgraduate period.