Low-Fluctuation Ink Supply & Maintenance for Pilot-Run IJP Platform

Kuo-Hua Wu, Wanda W. W. Chiu*, Chih-Jian Lin, Chien-Kai Chang, Cheng-Yi Wang, Chen-Chu Tsai & Kevin Cheng; Industrial Technology Research Institute, Hsinchu, Taiwan 310, R. O. C.*

Abstract

The ink-jet printing has the benefits of simple process, low ink running cost, easy to expend to large size panel application, as it was claimed prior years. But down to for real fabrication, the ink recycling and the service treatment are a big challenges to be solved. Different ink properties should be carefully designed its recycling process and minimum waste of ink during head cleaning, to save the ink expense in manufacture. This article discussed five issues in ink flowing: (a) the materials compatibility for ink and piping (b) the reduction process about low air bubble (c) pressure oscillation, (d) the flowing behavior with temperature change to high viscosity ink, (e) the mechanism for ink recycling and maintain,. In our calculation, the ink running cost will save 50% with the recycling device and refreshing mechanism, the replace time of ink can extend up to 4 weeks, and is possible used for real mass production.

Introduction

Imagine printing out electronic product or as partial process in display by ink-jet printing technology. Two converging technologies will make this possible some day—the ink-jet printing industry and the electronic materials industry. The world of ink-jet printed electronics includes: thin film transistor circuits (organic and inorganic), sensors, passive component, photovoltaic component, and displays (of all kinds, color filter, liquid crystal dispensing, polyimide layer coating), Low-cost printable electronic technologies provide opportunities to develop products that will change our lives.

Because of the increased functionality that comes with digital manufacturing, ink-jet printing capability can be one of the key drivers of the cannibalization of higher-end markets in the future. As multi-system inkjet heads are brought online and throughput is increased, the changeover to new digital production can be justified.

This article discussed the flow transportation and its recycling problem, and the refreshing as well as maintenance consideration on mass production. As a fabrication process, the ink consumption determined the expense of running cost. Besides, the stability of flow transportation will dominate by the factors of ink viscosity, air bubble within ink, the temperature variation along circulation path, the pressure drop due to the piping, and rework or deterging processes, and it need to be carefully design. We focus on discussion of (a) the piping & materials compatibility for ink (b) the de-gas design for ink flowing (c) the temperature variation (d) refreshing and maintain methodology (e) waste processing.

Flow System Construction

(a) the piping & materials compatibility for ink

In consideration of mass production, a stable, easy to maintain and reliable ink supply system is needed. Fig.1 showed an ink supply system for multiple print heads usage. The key components, like the ink supply tank, the through pump, the needle valve, the solenoid valve, and the piping, all these passage that ink flowing, needs to avoid the chemical reaction between the ink and said components, or the accumulation occur within these components. The general use of solvent to formulate ink includes the Water, Xylenes, Toulene, Anisole, Dioxane, TMB, Ethylbenzene, Benzene etc. To design, for general purpose, these components made of stainless 316 or 304, or aluminum alloy with anode treatment are preferred. Some ionic, catalyst, or polyelectrolyte ink, will cause the chemical reaction with metal, in our experience, the PEEK or HTPVC is suitable for those kinds of ink application, and for their mechanical strength and temperature endurance is better than common plastic materials.

Fig.1 showed an ink supply system. From the supply end to print head, it consists of a main chamber to store ink, a main pump to push ink flowing, a head tank to store high temperature ink; two filters were used for filtering the ink flow in and recycling. It is noted that a needle valve within the piping is to control flow rate by pressure choking. As mentioned before, most of inks their viscosity and wettability are function of temperature. To keep the ink flowing, especially for high thixotropic ink, the piping was enclosed by isolation materials to keep its temperature, and two heating probes at the main chamber and head tank to control temperature.

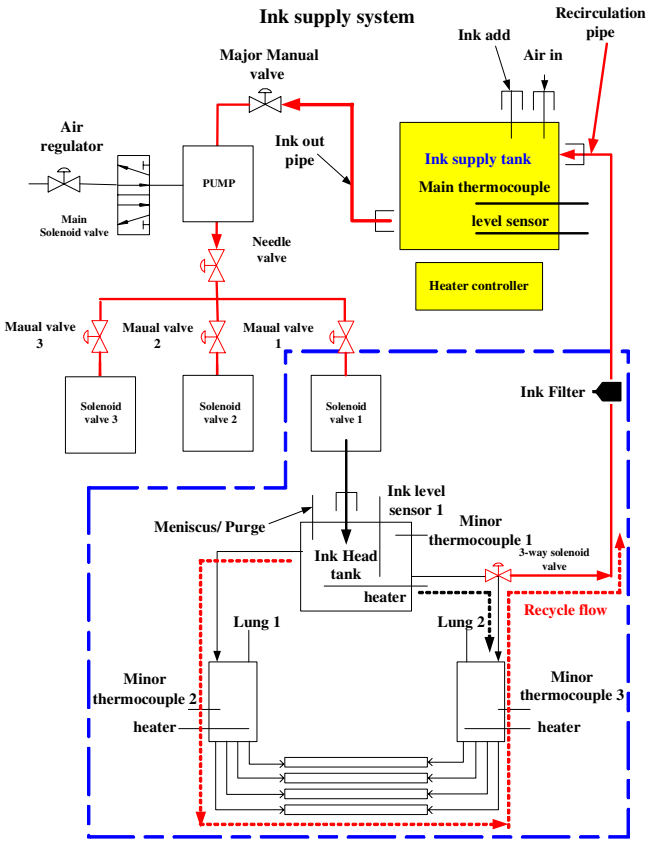

Fig. 1 Ink Supply System

(b) the de-gas design for ink flowing

The air bubble within ink flow will absorb the driving energy created by the actuator, the piezo film. It results the jetting deviation, blocking, and volume variation. Many possible reasons could make the air bubble within the ink. For example, at the ink filling process, the ink had not suitable stirring or separation of the air, then the air solve into the ink. Sometimes, it causes at the purging or suction process, because of the non balance of pressure during process period mad the air suck back into the nozzle channel. To solve this problem, three strategies adopted to keep air bubble from the ink. At the ink filling step, the ink will first heat to a certain temperature with a stirring device to drive out the air bubble solved in ink. As the ink is pumped into the main chamber, an ink / air separation device by pressure difference further abstract the air out of ink. Even with above operation, the air bubble could come from the nozzle due to the inappropriate operation of purging and suction. In this case, we operate a long continuous purge, to drive air in the ink out. Especially, when the ink recycling is operated, a vibration device equipped during the piping path to oscillate the air out from the ink, then the filtering ink return to the main chamber. This design can be effective to free of the air bubble creation in ink which deteriorates the jetting quality, and better yield performance is feasible.

(c) the temperature variation

For some inks, especially the case of non-Newton's fluid, two special physical characteristics need be carefully design in flow supply system, the thixotropic and rheologic properties. The thixotropic property describes the ink viscosity will decrease with time at same shear force applied, and the rheologic property will increase with time at same shear force applied. It means, while a stirring device within the ink chamber used for free of sediment, after a period of time, the flow characteristics will be changed, especially for high thixotropic ink. Fig.2 is a typical high thixotropic ink, while the ink was jetted down; it would not expend toward lateral, but accumulated like thorns. Therefore, in our design, for high thixotropic ink, like the legend ink used for printed circuit board, to avoid the low flowing occurs, the temperature control along the ink piping is needed, to modulate the ink flow behavior decay with time.

Fig.2 High thixotropic ink discharged down and its accumulation behavior presented.

(d) the pressure oscillation

The most important thing in piping design is the stability of back pressure control. A back pressure dominates the stability during drop-to drop jetting. In our original design, the pressure can be keep within ±0.1 mbar in tuning range of 3-20 mbar. However, when operated at high speed printing, the pressure condition will deteriorate down to ±1.4 mbar due to oscillation of piping and long distance of the transporting space, especially for large size printing platform. To solve this, as in Fig.1, a regulator and a needle valve were used for controlling the neck of flowing, to make the pressure chock and get fast balance of pressure during printing. Besides, all the piping will be in fixture or replaced as stainless piping as possible as; to prevent the oscillation occurs at relative moving. Fig.3 showed the tuning results of pressure, and presented a good jetting quality between nozzles.

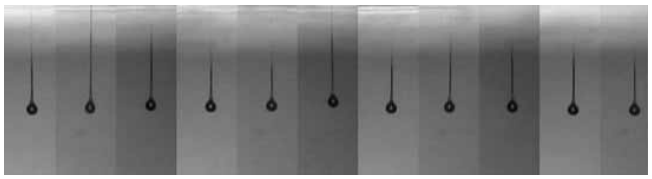

Fig.3 A tuning condition of pressure presented a uniform jetting quality for nozzles.

(e) recycling and maintain methodology

For high solid contents ink, the maintain station will be contaminated due to the sediment of ink. Here we design a refreshing mechanism by solvent compatible with the ink, to carry out this contamination. The piping with a 0.45 um filter inserted before the return port to prevent the particle mixing into ink, as shown in Fig.1. Fig.4 is a top view of the capping, suction, and refreshing mechanism, made of stainless 316. The waste ink drains into a collection bottle, and with a level sensor monitor its level condition. In our experience, the ink running cost will save 50% with the recycling device and refreshing mechanism, the replace time of ink can extend up to 4 weeks, and is possible used for real mass production.

Fig.4 Top view of maintain mechanism, two suction areas were at the top of picture, and a flushing area located at the center area, the bottom area was a capping area.

Conclusion

This article discussed the design issue about the piping and their concerning about the ink-jet printing, like the compatibility between piping materials and ink, the air bubble exists within ink, the wetting behavior due to the temperature, etc. Because of the high sensitivity at temperature and pressure stability for ink flowing and jetting stability, this article provided a significant solution in controlling. Also, we designed a refreshing and maintain mechanism to save the usage of ink, and to keep a long stable condition, three strategies for de-gas in ink were proposed. This design is suitable for real mass production in versatile applications and has the benefit of ink save, high stability, and friendly in maintenance.

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Biography

Kuo-Hua Wu received his bachelor degree in Mechanical Engineering from National Chung Hsing University in 1980. He is now a system integration engineer in the Printing Science Department, Display Technology Center, of Industrial Technology Research Institute at Taiwan. His work has primarily focused on the opto-mehantronic integration and the fluid mechanism design.

Wanda W. W. Chiu received her Master degree in Mechanical Engineering from National Cheng Kung University in 1996. She is now a deputy manager in the Printing Science Department of Industrial Technology Research Institute at Taiwan. Her work is primarily leading the industrial ink-jet printing processes and system integration. Her research interest covers the opto-mechanical system development, and specializes in ink-jet printing control and flow architecture design.

E-mail: wandachiu@itri.org.tw