Development of the Wide-Format UV Inkjet System “Acuity LED 1600”

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Abstract

“Acuity LED 1600” is a newly developed wide-format inkjet printing system, which has class-leading high productivity and excellent image quality for billboard or display application. New technologies including recently developed high-speed printing head, fast-curing UV-LED ink and proprietary-design LED light source achieves good print quality and wide-ranging expression by using color and transparent ink. Here, we report some unique features adopted in this printing press, which can be realized through FUJIFILM group’s own technologies in materials, ink, print heads, light source control, image processing and analysis.

1. Introduction

We have developed Acuity LED 1600, a wide-format UV inkjet printer used for producing large posters, POP displays, window displays and other similar applications. Acuity LED 1600 combines the class’s highest productivity of 20 m² per hour*1 with high image quality (Fig. 1).

Fig. 1  Acuity LED 1600 printer.

In the development of Acuity LED 1600, we have brought together FUJIFILM group’s technologies, including fine chemical technology and image processing technology of FUJIFILM Corporation, printing head technology of FUJIFILM Dimatix (FDMX) in the US and ink technology of FUJIFILM Speciality Ink Systems (FSIS) in the UK.

*1: It is the highest among roller-feed wide-format inkjet printers using UV-LED light source with a printing width of 64 inches or below.

2. Characteristics of Wide-format Printer Market

Wide-format printers are generally defined as those that produce 24 inches (61 cm) or wider print. The most common printing formats range from 44 inches (111.7 cm) to 64 inches (162.5 cm). The largest format is 197 inches (500 cm)1, 2). Printers vary in printing width, type of ink, printing speed and printing method. Manufacturers build their printers with a combination of technologies that best suits each target market.

More and more large prints, such as large posters and POP displays, are needing to be produced in a small lot, with short delivery time and many graphical designs. To meet these needs, printing process is going digital and the printing market using wide-format inkjet printers is expanding. Especially, UV inkjet printers are spreading because UV ink does not contain volatile organic compounds (VOC), dries quickly and is suitable for a wide variety of substrates, such as various types of plastics, besides paper.

A UV inkjet printer appeared at the end of 20th century. The UV ink was first adopted mostly in high-end printers, which were high in productivity and thus could make the most of the quick drying ink. In the sign graphics field in Europe, UV inkjet printers have been replacing multi-color screen printers to meet the needs for quick delivery and small-lot printing. The most commonly used printers in this field are a flatbed type. The fastest model of Inca Onset Series achieves productivity of approximately 650 m²/h, using 144 FDMX print heads for each color.

Manufacturers offer inexpensive entry-class UV inkjet printers with productivity of 10 to 25 m²/h. These printers use one or two print heads for each color and cannot achieve high productivity. Instead, many of them feature high image quality, keeping the minimum droplet size down to 10 pl or smaller level and using a multi-drop print head that can vary droplet size.

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3. **Aim of Development**

We have launched the development to build an entry-class inkjet printer that uses LED as the UV curing light source and combines high productivity and high image quality. And, we have come up with Acuity LED 1600.

3.1 **Using LED**

Most UV inkjet printers use metal halide lamps or high-pressure mercury lamps, which are high in output and suitable for large-scale production, as the UV curing light source. LED lighting, spreading rapidly for general lighting applications because of its long life and low power consumption, is also increasingly used as the UV light source for curing printing ink. UV-LED lamps are smaller in size and lower in heat generation than metal halide lamps and therefore suitable for UV curing on substrates vulnerable to heat, such as thin films. The peak wavelength is 365 nm, 385 nm or 395 nm. The light does not contain far-ultraviolet components and it does not emit an ozone odor.

**Selection of UV curing light source: Advantages of use of LED**

1. **Energy consumption**
   
   An UV-LED lamp consumes about a quarter of the energy a metal halide lamp does (approx. 0.5 kW).

2. **Life of lamp**
   
   UV-LED lasts more than 10,000 hours while a metal halide lamp lasts about 500 to 1,000 hours.

3. **Easier instantaneous on-off operation**
   
   Lighting only when required reduces energy consumption and prolongs the life of a lamp. That also eliminates the necessity of the mechanical shutter mechanism in a metal halide lamp unit.

4. **Lightweight and compact lamp unit**
   
   The carriage weight is reduced and a load on the chassis supporting the carriage is lessened.

5. **Heat generation**
   
   UV-LED generates less heat than a metal halide lamp and hardly deforms a thin plastic substrate.

3.2 **Graininess**

Acuity LED 1600 uses six color inks; cyan, magenta, yellow, black, light cyan and light magenta; to create smooth gradation and also uses white and clear inks to enhance the expressiveness. The printer is also improved in graininess, thanks to the multi-drop head FDMX has newly developed and the addition of light cyan and light magenta (Fig. 2).

3.3 **Printing on Lightweight Rigid Substrates**

Acuity LED 1600 prints on up to 13-mm thick rigid substrates and sheet substrates in addition to roll substrates.

4. **Technologies for Acuity LED 1600**

Acuity LED 1600 prints with the class’s highest productivity of 20 m²/h, thanks to Fast Accurate Marking technology that enables stable discharge of high-sensitivity ink and accurate positioning of ink droplets. That makes it possible to meet the end users’ needs for short delivery time. In addition, we have newly developed Intelligent Curing Control technology to adjust UV exposure conditions to individual printing jobs (Fig. 3).

4.1 **Fast Accurate Marking technology**

Acuity LED 1600 is equipped with a newly developed high-speed piezoelectric print head that discharges ink straight ahead and high-sensitivity UV ink. This is a marking system technology that combines high productivity and precise droplet positioning.
4.1.1 Printing Head

FDMX’s newly developed Q-class head (Fig. 4) has 256 nozzles arranged in a line. The printing width is 6.48 cm. Acuity LED 1600 has one head for each color. It discharges UV ink with a high drive frequency and positions the ink droplets precisely. This is Fast Accurate Marking technology. Thanks to this technology, the printer achieves the class’s highest productivity of 20 m²/h and meets the needs for short delivery time. The Q-class head is an industrial print head designed for scanning that employs a drop-on-demand system. The head is high in performance, great in durability and high in reliability (Fig. 5).

The print head has two ports as liquid interface. That makes it easier to flush the manifold that supplies a liquid during ink replacement or flushing with a wash.

The Q-class print head is designed for scanning applications that require multiple heads to fit into a small space. The head discharges ink downward. It has liquid interface and electric connections on top. Because of this design, the head is as thin as 8 mm (at the mounting bezel) in the scanning direction and that makes the entire head unit compact. Combining this new print head with the lightweight UV-LED unit downsizes the carriage consisting of eight-color print heads and the lamp as well as increasing the scanning speed.

![Fig. 4 Newly Developed Q-class Printing Head.](image)

4.1.2 Ink

Ink used for Acuity LED 1600 is UV curable ink (UV ink), which is excellent in drying property and processed quickly. Inks used for wide-format printing are roughly divided into two types: Solvent ink containing a volatile solvent is dried by heating and UV ink containing a reactive monomer is polymerized and hardened by UV light. To polymerize UV ink, free radical and cation methods have been researched. Now, the free radical method is widely used. We use this method for Acuity LED 1600 and many other UV ink products. Free-radical UV ink has the following advantages over solvent ink. (1) Ink cures instantaneously when exposed to UV light and that saves time required for removing the solvent between printing and postpress. When solvent ink is used, residual solvent in the ink film must be vaporized before postpress, such as cutting and laminating, is started and it takes about a day. (2) As the ink contains no volatile organic compounds, it has less impact on the environment.

Typical UV ink consists of photopolymerization initiator, reactive monomer, resin, pigment, pigment dispersant and additives (e.g., stabilizer and surfactant) (Table 1)³.

Acuity LED 1600, to achieve high productivity using the UV-LED light source, uses high-sensitive ink newly developed by combining (1) a photopolymerization initiator with the sensitivity range extended to near-UV light and (2) a monomer formula immune to oxygen inhibition of polymerization and great in surface curing.

![Fig. 5 Linearity.](image)

<table>
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<th>Table 1 Composition of UV Inkjet Ink.</th>
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<td><strong>Free radical</strong></td>
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<td>Monomer</td>
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<td>Pigment</td>
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Fig. 6 shows the absorption spectrum of the initiator for Acuity LED 1600 compared with that of our initiator for a metal halide light source. The initiator for Acuity LED 1600 ink hardly absorbs the light in the visible light range (400 nm and above) not to affect the color reproducibility of the ink while it has sensitivity that corresponds to the emission peak wavelengths of the LED light source.

Curing property is enhanced by using a multifunctional monomer, which has multiple reactive groups in a molecule. But, the flexibility of the cured film is reduced. It is not suitable for printing roll substrates, which Acuity LED 1600 is used for.

To produce high sensitivity ink suitable for roll substrates, we have developed a formula that increases adhesiveness of ink film surface using a monofunctional monomer, which has high elongation and adhesion.

### 4.2 Intelligent Curing Control Technology

The UV-LED light source is compact in size and easy in switching. Making the most of these advantages, we have designed a new lamp unit to control ink curing speed and achieved (1) improvement in ink adhesion to poly vinyl chloride substrates and (2) simultaneous printing of two layers different in exposure conditions: color and clear ink layers.

#### 4.2.1 Lamp Work

A typical UV wide-format printer, to prevent droplet interference, has the lamp placed on a side of the print head and exposes the ink droplets to the UV light immediately after they hit the substrate with the same intensity throughout from the first pass to the last of multi-pass printing (Fig. 7a).

A metal halide lamp and a mercury lamp are high in output and suitable for high-speed printing. But it takes long for the output to stabilize at startup. The lamp also has to stay on while the printer is on standby. The illuminance changes significantly with time. It is difficult to keep the light quantity constant.

Acuity LED 1600 uses a minimum pinning exposure system to accelerate wetting and spread of droplets and their penetration into a poly vinyl chloride substrate. UV lighting is performed by the pinning exposure unit to prevent droplet interference and the curing unit to harden the droplets completely (Fig. 7b).

Acuity LED 1600 is greatly improved in ink adhesion to poly vinyl chloride substrates, widely used materials for banners. The printer gives printed products enhanced durability during installation and display. Fig. 8 shows poly vinyl chloride substrates printed with a conventional printer and Acuity LED 1600. We have applied adhesive tape to the central part of each print and then peeled it off. Acuity LED 1600 demonstrates great adhesion strength.

![Conventional Printer vs. Acuity LED 1600](image)
4.2.2 Simultaneous Multi-layer Printing

Acuity LED 1600 uses clear ink. The printer can give a glossy finish to the whole print or a particular part of it on demand, which broadens expressiveness of prints. To make the printed surface smooth with clear ink, time must be allowed for wetting and spread of droplets. To allow for the time, the lamp needs to light some time after the color printing. However, with the conventional lamp work technology, it is difficult to execute multiple different lighting conditions simultaneously in one job. We have divided the operation into two phases: The color heads print upstream and the clear ink head discharges downstream. The lamp operation is also divided. The upstream lamp is switched on to pin the color droplets and the downstream lamp is switched off to smooth the clear droplet surfaces. To finish up, the curing lamp unit hardens the whole print completely (Fig. 9). This system was complete when we have found a compact LED light source that switches on and off quickly.

![Paper feed direction](image)

Fig. 9 Curing Process for “Color + Clear” Printing Mode, Side View.

This system makes it possible to perform color printing and clear finishing, which are different in exposure condition, simultaneously without having to wind back a substrate roll. It also enables simultaneous color and clear printing with sheet paper fed only once and ensures a quality finish without misregistration.

The curing lamp unit can be moved to a position where it can emit UV light onto droplets immediately after they are shot. Therefore, the printer supports simultaneous multi-layer printing with color and white, which requires high UV intensity.

5. Conclusion

The UV inkjet system, thanks to its high speed printing capability, is increasingly spreading in the sign graphics field. The inkjet system hardens ink droplets on a substrate instantaneously on demand and non-contact. Because of this feature, the system is expected to become widely used in various other fields, too. We will continue to improve the technology supporting the system, combining all the element technologies for material, ink, print head, droplet control and lamp work.

References


(In this report, application for trademark registration of “Acuity” has been made by FUJIFILM Corporation.)