HP Designjet L65500 Drying and Curing Systems

Jesus Garcia Maza; Large Format Printing R&D, Hewlett Packard; Sant Cugat del Valles, Barcelona, SPAIN

Abstract

The HP DesignJet L65500 printer has been the first water based latex ink printer in the market. Using very high npi TIJ print heads, like many other HP large format printers, the image quality it produces is outstanding; but what really makes the difference is the latex ink it uses.

HP latex inks are specially formulated to work well on vinyl and other plastic surfaces. Like all other HP water based inks its main ingredient is water which is the vehicle that carries everything else. They have pigments and a few other ingredients that keep pigments dispersed in water and that enables it to wet plastic surfaces. And finally they have little balls of latex.

During the printing operation a thin layer of ink is laid down onto the media. This ink contains the required pigments to form the image, and an evenly distributed load of little latex balls.

It is then when the drying system actuates. The drying system evaporates an important fraction of the water to keep pigments in its place, ensuring a good image quality. The drying system is based on infrared emitters which heat up the media, and some blown air which evacuates the water vapor. The thermal profile the media sees has been optimally designed after long investigations to produce the desired results; but temperature peaks at about 50° C.

Then the image enters the curing zone. The curing system raises the media temperature even higher, and its main objective is to finish evaporation of any remaining water and additives and to form the latex film. When all the water is evaporated, the little balls of latex get in close contact with each other; and when its temperature raise above its glass transition temperature latex macromolecules start to move. This molecule diffusion movement generates a continuous film of latex which encapsulates the pigments and makes a durable output. Typical curing temperatures are about 90ºC. As the film formation is a diffusion process, it takes some time. Time required for the molecules to diffuse and to generate a continuous latex film is a direct function of the temperature reached. In an HP DesignJet L65500 printer using a typical production print mode the print is held at curing temperature for 30 seconds approximately. The curing system is based on infrared emitters as the drying system.

The drying and the curing systems in the HP DesignJet L65500 printer are basically infrared emitters which behave close to black bodies working at 900 K. The emitters and their working temperature have been chosen to get the maximum matching between the emitted radiation and the absorption of both, plastic media and water based ink. Water infrared radiation absorption is maximum at 3 µm wavelengths and typical plastics absorb very well at 3.4 µm. A black body at 900 K radiates with a peak of emitted power at around 3.2 µm, very well aligned with both absorption peaks.

Finally, both systems have infrared (non contact) temperature sensors which directly sense media temperature, used to drive a closed loop temperature servo.

Introduction

Latex is a descriptive term for aqueous-dispersed polymers; and in the case of the HP Latex inks, the term Latex means that polymer particles are dispersed in the ink. The polymer used in HP Latex inks is a synthetic polymer, chemically different from natural rubber latex, so HP Latex inks are non-allergenic.

HP Latex inks were designed with the environment in mind:

- No special handling required
  - Contain no materials requiring hazard warning labels (world-wide)
  - Non-flammable and non-combustible
- Prints emit extremely low levels of VOCs
  - Co-solvents and their concentrations in HP Latex Inks are similar to HP's aqueous Designjet inks used WW in office environments without special ventilation
- No special workspace ventilation required
- No ozone emissions
- No Hazardous Air Pollutants (HAPs)
- 3-liter HP 786 Latex Designjet Ink Cartridges were designed to reduce use of materials and to maximize usable ink

HP Latex inks are water-based, and compatible with a wide variety of media as low cost, self-adhesive vinyl, papers and polyester fabric, uncoated media, etc… They are suitable for broad indoor and outdoor applications, like vehicle wrapping, wall paper, etc… They are highly flexible, allowing media to stretch and conform as required by the application. Prints are odorless, dry and ready to use out of the printer. Any required post process can be done immediately after printing.

In order to have a dry and ready to use print, the HP DesignJet L65500 has Drying and Curing systems which finish the print forming a continuous latex layer which protects it, producing a durable output both for indoor and outdoor applications.

The Printing Process

The HP DesignJet L65500 printer uses, as many other HP printers, a scanning configuration to print. It has a media movement mechanism which moves the media in steps of a predetermined size with high accuracy. After each media movement, and while the media remains still, there is a carriage which moves (scans) on top of the media carrying the print heads which generate the drops of ink that lay down onto the media.

By repeating this process and by precisely selecting which color ink drop is placed in every piece of media, the image is formed.

In Figure 1 there is a schematic cross-section of the HP DesignJet L65500 printer which shows the media on top of the print zone, the print head carriage, the drying system, and the curing system.

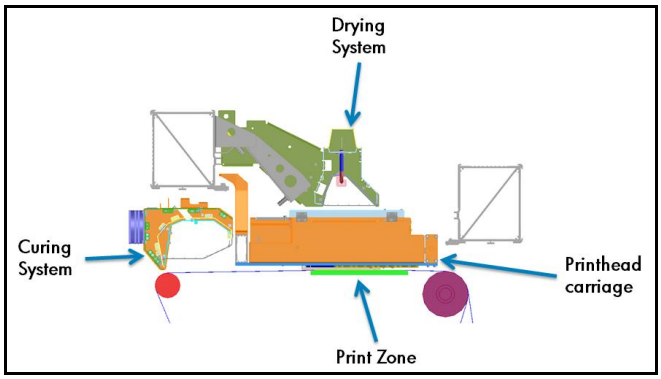

***Figure 1**. DesignJet L65500 cross-section*

The Drying Process

As soon as ink is laid down onto the media, the drying process starts. The drying process consists of removing most of the water vehicle from the thin layer of ink. Once water is removed, pigments loose mobility and keep in place, thus maintaining image quality.

The drying process must remove most of the water, but must leave inside the ink layer as much ink additives as possible to enable them make their function. This limits the temperature that can be used for the drying process. Recommended temperatures for the HP DesignJet L65500 drying process are around 50° C. The physical elements that heat up the ink and the media up to ~ 50° C in the drying zone are infrared resistors with an aluminum reflector placed on top of the printing zone (the drying zone and the printing zone are the same because drying must start just after printing). The temperature of the ink and media is measured in real time by an infrared sensor which points to the drying zone. Finally, the ink and media temperature is kept constant by adjusting the power given to the IR resistors every few seconds based on the temperature IR sensor measurement.

In Figure 2 there is a schematic cross-section of the HP DesignJet L65500 printer which shows the drying system, including the IR resistor, the reflector and the sensor.

In order to improve the mass transfer process, there is an array of blower fans (shared by the drying and the curing systems) that blow some air to the drying zone.

The fact that the drying zone is the same as the printing zone adds two difficulties to this system:

1. Air speed must be low to avoid moving the ink drops.
2. The print head carriage is continuously moving between the media and the drying system, affecting the way the heater works and the sensor measurements.

The print carriage passing periodically under the temperature sensor is a problem for the temperature closed loop servo, which needs a means to filter out this disturbance.

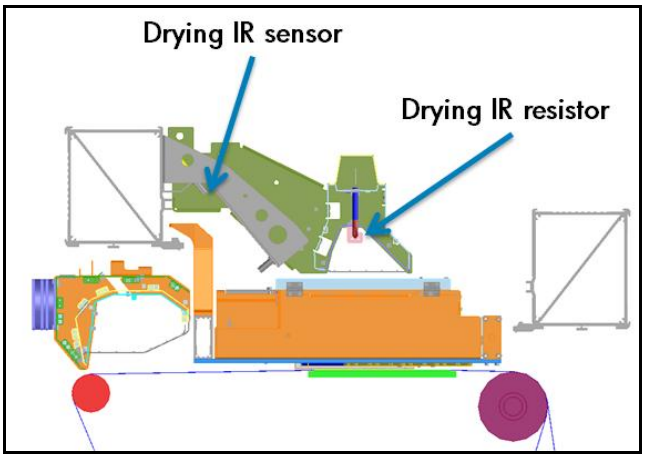

***Figure 2.** DesignJet L65500 Drying System*

In Figure 3 there is a schematic representation of the drying process. After all water is removed, a thin layer of pigments, latex particles and some ink additives is left on top of the media.

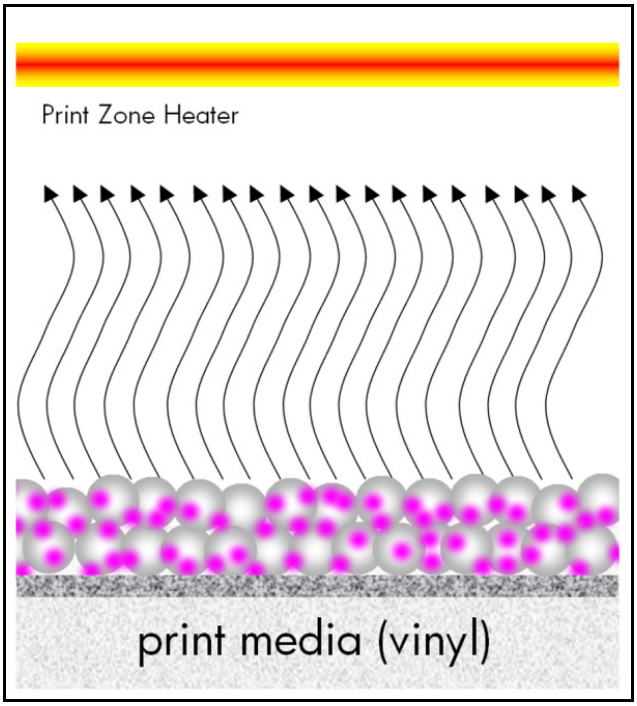

***Figure 3**. Drying Process*

The Curing Process (Latex film formation)

Just after the drying process is finished, the curing process starts. What is left at this stage is a piece of media with a thin layer of pigments, latex particles, and ink additives, all mixed together on top of it; and what needs to happen is:

1. Ink additives must evaporate.
2. Latex particles have to coalesce and form a continuous film, encapsulating pigments.

In Figure 4 there is there is a schematic cross-section of the HP DesignJet L65500 printer which shows the curing system, including the IR resistor, the reflector, the sensor and the fan array (that blows air both to the drying zone and to the curing zone)

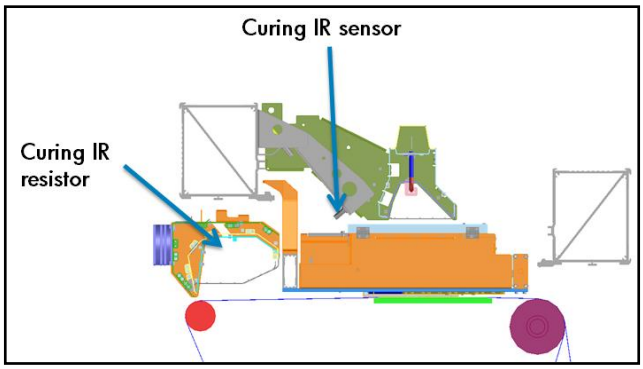

***Figure 4**. DesignJet L65500 Curing System*

Ink additives have lower vapor pressure than water, thus requiring higher temperatures to evaporate. Recommended temperatures for the HP DesignJet L65500 curing process are around 90° C. The physical elements that heat up the ink and the media up to ~ 90° C in the curing zone are infrared resistors with an aluminum reflector placed on top of the curing. The temperature of the ink and media is measured in real time by an infrared sensor which points to the curing zone. Finally, the ink and media temperature is kept constant by adjusting the power given to the IR resistors every few seconds based on the temperature IR sensor measurement. In order to improve the mass transfer process, there is an array of blower fans (shared by the drying and the curing systems) that blow some air to the curing zone.

Once all ink additives have been evaporated, the latex particles can coalesce together, and by keeping them at the right temperatures, the latex molecules start to diffuse in the borders between latex particles. After some time, the boundaries between particles disappear and a continuous film of latex is formed which encapsulates the pigments.

In Figure 5 there is a schematic representation of the latex film formation process.

The latex film formation process is a diffusion process, so it has some properties:

1. Temperature must be above the Tg temperature of the Latex because Latex molecules can move only when its temperature is higher than its glass transition temperature (Tg). Actually this is true for pure latexes, but in the case there are other additives, temperature must be above MFFT (minimum film formation temperature) which typically is lower than Tg.
2. The time to form the film strongly depends on the type of latex (molecules size and shape) and on the temperature, so the higher the temperature, the lower the required time.

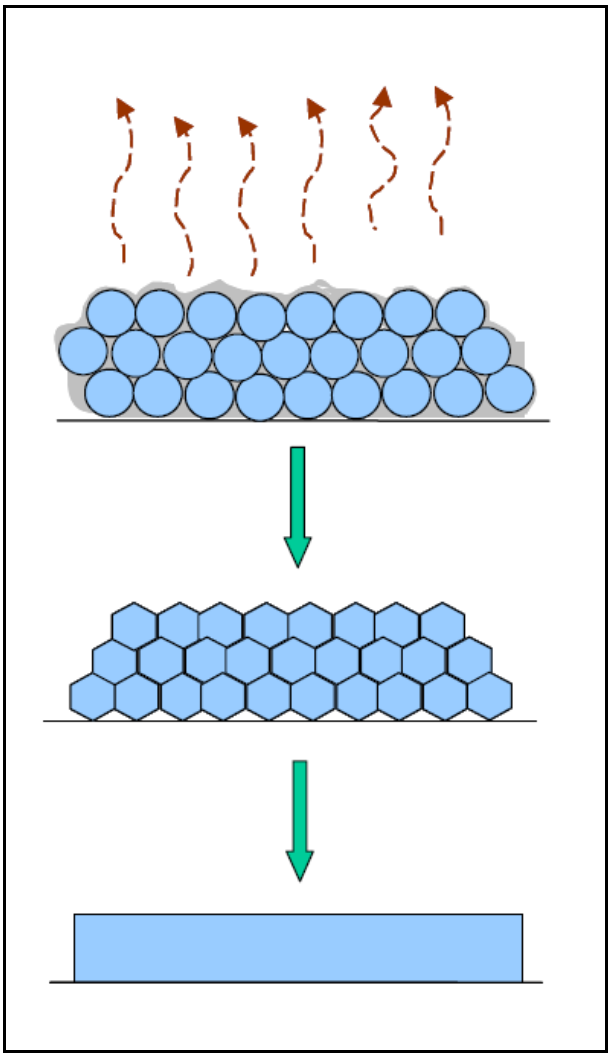

***Figure 5**. Latex Film Formation*

The curing process in the HP DesignJet L65500 requires temperatures around 90° C for about 30”, but they could be as low as 70° C for longer times.

In Figure 6 there is a media temperature profile as the image travels through the printer.

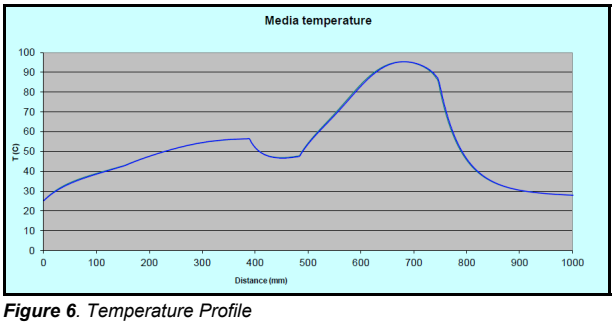

***Figure 6**. Temperature Profile*

The film of latex protects the pigments against abrasion, water and other solvents, making a durable image, both for outdoor and indoor applications.

References

[1] Joseph L. Keddie – Alexander F. Routh, Fundamentals of Latex Film Formation (Springer, 2010).

Author Biography

Jesus Garcia Maza received his Master degree in Mechanical Engineering from the Universitat Politecnica de Catalunya in 1991. Since then he has worked in the Large Format Printing Division at Hewlett Packard in Sant Cugat del Valles (Spain). He has been working as Chief Engineer of Latex Industrial Printers for many years, focusing mainly in new technology development.