Quality Limits for the Future Development of Digital Printing

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Abstract

The paper is dealing with technological aspects of digital printing technology. All existing principles of digital printing will be investigated in respect of their physical and chemical limits in imaging. Resolution, speed, duration of prints, color accuracy, color gamut, edge sharpness, uniformity of solids will be examined and the possible further developments will be discussed and problems with physical and chemical limits for quality developments will be pointed out. Also problems with material as toners, inks and substrates suited for digital printing will be listed and also put in an overall list with the other physical and chemical limits of digital printing technologies. As a conclusion different technologies will be rated about their chances for future developments in respect of speed, resolution and durability of printed products.

Introduction

Digital printing is a fast growing technology of the new millennium, and the limitations for future development should therefore be investigated with respect to the physical and chemical and printability parameters.

The main technologies for digital imaging are:

1. Ablation
2. Electrophotography
3. Magentography
4. Electrography
5. Ionography
6. Ink-Jet
7. X-graphy
8. Thermography

With regard to growth rates and technology forecasts the most important technologies are electrophotography and ink-jet. They were chosen therefore for closer investigation into the most important scientific facts upon which the methods are based.

Conventional printing is using a master and ink. Non-impact technologies in digital printing are masterless and using different processes and materials.

Electrophotography, Ionography powder toner and liquid toner.
Electrography special coated paper.
Magnetography magnetic toner
Ink jet liquid ink, hot melt ink.
Thermography color donor ribbons, foils.
X-graphy ink and toner.

Physical Limitations

The physical limitations are mainly imposed by the following parameters:

- Speed
- Temperature
- Pressure
- Transfer time
- Viscosity
- Surface tension
- Electrical behavior

These parameters provide a basis for a first comparison between the different systems mainly concentrated on ink jet and electrophotogrphy. It is important to note that that especially electrophotography and ink jet have totally different modes of operation by which the image is transferred from a digital file to the paper surface

Electrophotography

Electrophotography is a technology, where a latent image is formed on a photoconductor mainly on an OPC (Organic Photoconductor) surface. Here, speed is a limitation to consider. The main parameters are the charging speed of the photoconductor surface and the speed of the imaging process, which, via laser technology, involves selectively discharging the OPC surface.

The toner is then transferred to the charged surface, mainly a drum surface, and from the surface it is transferred to the paper surface, where it has to be fixed via temperature, heat, light (UV or IR) or chemicals. Many individual time factors have to be considered during the printing and imaging process. The electrical behavior of the

paper clearly plays an important role in the efficiency and quality of this process.

In electrophotography, the predominant process for fusing toner to the paper is hot-roll fusing. In this process, fixing the toner to the paper involves liquidification, coalescence or sintering, spreading, penetration into capillaries, and resolidification. This includes the interactive effects of physical process variables such as temperature, pressure and lubrication

Ink-Jet

In- Jet is a direct imaging process, where ink, mainly in liquid form, is passed via jets directly onto the paper surface.

The only time limitation is in the forming speed of ink droplets of the right size.

A drop ejection rate up to 30kHz is possible. Speed is therefore a great advantage in ink-jet printing and physical limitations do therefore not really exist in future.

The basic mechanisms that determine the functionality of the process include the interaction between drops, the evaporation of the carriers in solvent-based inks, the solidification of hot-melt ink drops, and the curing of UV-cured inks after the drops strikes the substrate. Static and dynamic factor influence the time- dependent phenomena of absorption and spreading of single drops and the interaction and coalescence of multiple drops.

Comparison of Physical Limitations

	Ink- Jet	***Electrophotogr.***
Speed	*unlimited*	*too many transfer steps*
Temperature	*ok*	*very limited*
Viscosity	*limited*	*limited*
Pressure	*jet limit*	*no real limit*
Transfer time	*unlimited*	*very limited*
Electrical behavior	*no real limit*	*very limited*

All the physical limitations arise mainly with electrophotographic systems. Also ionography and magnetography have similar problems according toner technology problems.

Imaging is in both processes quite easier therefore according speed there are no really limits for magnetographic processes on the other hand till now it is only possible to work with b/w and very limited resolution parameters.

Ink- jet systems have actually no limitations. The main problems are the difficult drop-producing processes must be handled properly.

Chemical Limitations

The main chemical limitations of digital processes arise from two main parameters:

- Toner and ink
- Paper and other substrates

Electrophotography

The quality of this process is determined by the toner particle size. Normally solid toners are used and the particle size for producing solid toners is very limited.
Following parameters have to be considered:

Liquidification
Coalescene or sintering
Spreading and penetration
Toner resin technology
Toner softening
Melting temperatures
Fuser and pressure roler elasticity
Surface energy
Wetting adhesion characteristics

A color toner particle is composed typically of polyester resins to 95% and it is 7-13 microns in diameter.

In the past the mechanism of adhesion was believed to be a mechanical interlock of toners and fibers. We know today that is not even true for plain paper, where the sizing has a profound effect on agents, normally a metal organic complex or quat polymer wax in the form of polyalkylene as fuser release and surface additives in the form of fumed silica or metal oxide for flow properties.

Ink-Jet

The basic mechanisms that determine the shape and size of dots on the substrateare:

Absorption
Spreading of ink drops
Interaction between drops
Evaporation of the carrier

Spread is determined by the thermal characteristics of the ink. Therefore the ratio of drop energy availability to the substrate heating requirement determines the ink-jet imaging.

Drying Characteristics

Electrophotography

The heat transfer properties include bulk conductivity, specific heat, and thermal resistance.

Ink- Jet

Solvent based inks- drying controlled by absorption and evaporation

Oil based inks- drying controlled by absorption

UV-curable inks- drying controlled by absorption and the time available before cure

Hot-melt-ink- drying controlled by freezing

Printability Limitations

Parameters which are important for digital printing are:

**Resolution and adressability*

**Dot size = dot pitch*

**Raggedness = dot radius*

Normally the number of grey levels is equal to the number of dot sizes.

Adressability and grey levels for different technologies

Technology	*Adressability*	*Grey levels*
Electrophotography	*25-1200*	*2*
Printing	*75-150*	*50-256*
Ink jet	*120-1440*	*1-2*

Print Quality limitations are:

DOT

Dot location
Dot gain
Dot shape
Edge ragegedness
Satellites

LINE

Line width
Edge sharpness
Edge rggedness
Optical density
Resolution (Modulation)

SOLID AREA

Optical density
Color
Noise (graininess, mottle, background,ghosting)
Gloss

The ideal procedure on an uncoated paper is for the paper to emerge with toner conformed to the surface, and for coated paper to emerge with the toner at least partially dissolved in the coating. Especially in color images, the mismatch between hygroexpansitivity and thermal expansitivity of toner and paper can cause curl.

Conclusion

A comparison between different digital printing technologies was mainly done to compare electrophotography and ink-jet. In sense of limitations in print and printability and quality there are no real differnces between ink-jet and elctrophotography ionography and magnetography are still very limited. Quality is the domain of ink-jet, electrophotography an special thermo technologies.. So far, if quality results and speed are taken in consideration, electrophotography gives better performance. In b/w magnetography is far ahead also in the respect for its possibility to print master and masterless.

In future, and on the basis of dry toner technology in electrophotography, ionography and magnetography, ink-jet has a rather better outlook than dry toner technologies. The process of the future in a new digital world is therefore the direct- to- paper technology represented mainly by ink jet.

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Biography

Werner Sobotka received his Engineer degree from Vienna school of printing for graphic technology and printing, Master of Science from Technical University of Vienna and a PhD. In Technical Sciences from the Technical University of Vienna. He is professor for Communication at Zargreb University and Technical University in Vienna, CEO of the graphic research centre for multimedia in Vienna (VFG), Chairman of the standard committee for electronic publishing, editor of Print & Publishing in Austria, Poland and Russia. He is a member of IS&T, representing Austria in CEN and ISO and winner of the Gutenberg Award 2000.He is also liaison officer between ISO and CIE and autor of several books in the field of digital printing.