The gap between environmental considerations and durability of non impact printed products on different substrates

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Abstract

Durability and environmental aspects of non impact products are not always working together. Especially substrates specially designed for long lasting non impact prints causing environmental problems during recycling the products. The deinking process and also energy consumption, air pollution and waste water treatment and hazardous waste is more complicated.

1. Printing technologies

Digital printing is the most important technology for the next decades and the limitations for future development should therefore be investigated with respect to environmental considerations and the durability of the produced products. The main digital printing technologies investigated in these respects is ink jet and electro photography. Electro photographic imaging is used mainly in fast working digital printing presses and copiers and uses an electrostatic photoconductor, where the images are created by a corona discharge and the imaging is done mainly by PDF –driven lasers. Dry or liquid electrically charged toners are then transferred via the photoconductor onto the paper. In ink jet there are several ink jet technologies available transferring ink directly to the paper surface. Therefore the structure and chemical composition of the paper surface and the chemical composition of ink and toner are the main factors for durability of the produced prints and also for the deinking properties and the resistance against water and light fading and mechanical influences on the printed surface, if outdoor materials are produced. The physical limitations are mainly imposed by the following physical parameters:

Speed
Temperature
Pressure
Transfer time
Viscosity
Surface tension
Electrical behavior

These parameters can be influenced through chemicals and by composition of the surface of the substrate. In electro photography, the predominant process for fusing toner to paper is hot roll fusing., or working with elctroinks and liquid toners. In this process, fixing the toner powder 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 and an optimal composition of the chemical components to fulfill these processes. In inkjet we are talking about a direct imaging process, where ink, mainly in liquid form, is pressed via jets directly onto the paper surface. The only limitation is in forming ink droplets of the right size. Speed is therefore a great advantage in ink jet printing and physical limitations do not really exist. 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 factors influence the time dependent phenomena of absorption and spreading of single drops and the interaction and coalescence of multiple drops. To get good results for durability the adhesion on the paper surface must be excellent and better adhesion on paper surface is on the other hand not very good for deinking in electro photography or if the ink an toner particles are penetrating in the paper surface no good deinking is anymore possible.

2. Chemical Limitations

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

*Toner and ink
*paper or other substrates

The quality of the electro photographic process is determined by the toner particle size. Normally solid toners are used and the particle size for producing solid toners is very limited. The toner particles have to be transferred to the paper and then in most cases, hot roll fused, Another technology is UV-curing, which gives in most cases a perfect durability of the printed surface but the deinking is not really possible. The fixing of the toner powder to the paper involves liquidification, coalescence or sintering, spreading and penetration into the paper surface. Material variables are also critical and the toner resin rheology, toner softening and melting temperature are very important and also the chemical composition of liquid electroink toners. The fuser and the pressure roller elasticity and the wetting and adhesion characteristics of the toner also play important roles. A color toner particle is typically composed of polyester resin to 90-95% and is about 7-13 microns in diameter. In the past, the mechanism of adhesion was believed to be a mechanical interlock of toner and paper fibers. We know today that is not even true for plain paper, where the sizing has a profound effect on toner adhesion. In the color pigment dispersion we find the charge control 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 oxides for flow properties. Designing the formulation of these components is always a compromise between optimal durability and surface resistance properties as light fastness, water resistance and rub resistance on one hand against good deinkability or environmental hazardous free components of the process on the other side. Especially designing of good paper for long lasting substrates for excellent outdoor properties involve a lot of chemicals and surface treatments, which are not really environmental friendly. The fusing

process goes through several steps. Although we only wish to heat the toner, or most the toner-paper interface, heat is mainly lost to the substrate.

Process fixing toner to substrate

Liquid toners are extremely fine in toner particle size and simulate the offset process. On the other hand, they are no water-based systems and the solvents are not easy to handle and cause a lot of environmental problems.

Ink jet

The basic mechanism that determines the shape and size of dots on the substrate include the absorption and spreading of ink drops. The interaction between drops, and evaporation of the carrier in solvent based inks. In solid ink jet, spread is determined by the thermal characteristics of the ink. Therefore the ratio of drop energy to the substrate heating requirement determines the ink-jet imaging.

3. Material Parameters

The paper surface or the substrate surface beside the electrical behavior of paper plays an important role for electro photography. These properties are very moisture-sensitive. In most cases, the assumption that the electrical behavior of paper is ohmic is not sufficiently accurate, especially in the case of a dielectric relaxation process in semi-insulating materials. Therefore the formation of paper is very important. Since paper is made of cellulose fibers and virgin fibers are better distributed randomly as recycling fibers, there is a non-uniformity in the distribution in the plane of the sheet on a scale of the order of 1 to 5mm. Paper formation affects the uniformity of toner transfer and the quality of the resulting image is always better with virgin fibers. The right engineering of paper for digital printing is not easy and in most cases a lot of surface treatment is necessary to give paper a good durability, light fastness, water resistance and handling. In most cases paper has to be really white and therefore fibers are bleached and also brighteners and whiteners are used, which are not very useful for durability and light fastness.

In liquid ink-jet printing, a critical quality issue is the coalescence of the ink on the paper surface. The paper coating is especially important in ink-jet printing. The roles of surface tension of the ink, the surface energy of the substrate and the rate of absorption by the substrate are very important for the mechanisms of coalescence.. The most important task for ink jet is to find the right coating in combination with the right ink- jet technology to get the best results, especially for the speed and durability of ink jet printing. The surface tension of the ink jet ink and the surface energy of the substrate play complimentary roles in coalescence. The main factor is the ink-substrate interaction, which determines the quality for durability, water resistance and rub resistance and in most cases the coatings and inks used therefore are not environmentally friendly and also not easy deinkable. The important factor therefore is the ink substrate interaction and the right formulation of inks and coatings of substrates. In most cases the durability components are causing problems for deinking and also inks and solvents used are not environmentally friendly.

+ *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 (especially environmental risky process)
+ *Hot-melt Ink* – drying controlled by freezing

4. Durability Considerations

For durability we can consider outdoor and indoor situations. All prints intended for long term display should have special designed inks mainly pigmented in inkjet or special designed toners. Also the ink/paper combinations or the surface treatment of substrates for outdoor is very important. It is quite more difficult to make the prints resistant against “Gas fading” and “ozone”.Changes in image color and density, and /or image diffusion (image bleeding) are especially beside the composition of ink and substrate a humidity problem. Low humidity is very good for durable prints .. Also water fastness can be rated as “high”, “moderate”, and “low”, Good water fastness is always combined with the use of special inks and special designed paper or substrate surfaces and can not be deinked easily in most cases they are not deinkable at all. A big problem are fluorescent brighteners (also called “ UV brighteners”, “ optical brighteners” or OBA`s “ optical brightening agents which are parts of the image side coatings of many inkjet papers – and nearly all copying papers made of virgin fibers- to make them whiter and “ brighter”. Normally the use their effects in making the paper look whiter, but very soon the paper is yellowing very quickly. Therefore for durability purpose brightener free paper will be quite better for archivation, but more difficult for printing. Another potential drawback of brighteners is that brightener degradation products may themselves be a source of yellowish stain. For archivation and long lasting large format prints papers and substrates with fluorescent brighteners should be avoided. To get better resistance overcoats made especially for inkjet prints can be used. A similar process can also be used for making inkjet prints better deinkable.

5. Conclusion

Putting all facts together there is a big gap between durability, usability and environmental friendly produced prints as well in ink jet as in electro photography. Durable and very resistant prints for photo books, for outdoor applications and also for displays are only possible if a special treatment of the paper and substrate surface has been applied and UV-curing for outdoor and special drying methods need a special composition of ink and toner . If the products can be recycled easily, they are normally not long lasting, not really good rub resistant, water fastness is poor and a long-term light fastness can not be reached.

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