Production with UV-Screen Inks

Necessary Considerations with respect to...

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Basically screen printers have to pay attention to various aspects to ensure trouble-free production. When printing with solvent based inks attention is required to the printing process itself. However, when working with UV-inks more attention is required with respect to curing, measurement and testing. Specific properties and characteristics of the ink have to be considered first, just like with solvent-based work. In that respect we would like to point out a few general characteristics, which are typical for UV inks.

PRINTING WITH UV INKS

There is no such thing as the UV-Ink!

In the meantime a variety of UV-screen inks are available for various applications. Thus there are also a variety of different properties of these various UV ink systems.

Screen printers can take advantage of the specific properties of UV-inks in their production processes, however, some aspects have to be considered.

The known advantages of UV-inks are

- **screen stability**
- **constant colour shades**

Screen Stability
is unlimited. On the other hand this also means:

- One should avoid influence of UV light – either sunshine or excessive artificial light. Especially highly reactive UV flash cure inks react under even low amounts of UV-radiation in day or artificial light conditions and are subject to pre-reactions in the can or the screen. Such systems are especially sensitive to UV-A light contained in the regular light spectrum.
- It is important to control retouching of stencils – even the finest screen openings will print ink.

Printing

- When printing high numbers, colours will stay more constant than with solvent based systems, as UV-inks only have a low content of evaporative components.
- However, due to the specific circumstances of four colour process work, image changes caused by growth of tonal value due to dot gain are also possible!
- Often squeegees with higher shore hardness (75-80) are used.
- Printers cannot influence viscosity of the ink like they can with solvent inks.

Cleanliness
is essential! UV-inks do not air dry. Ink drops on floors, clothing, skin will be transferred everywhere.

...PRINTING

UV-CURING – THE UNKNOWN FACTOR FOR UV-TECHNOLOGY BEGINNERS

Working with UV-inks requires the use of a UV-drier. For successful production runs, this equipment has to be adjusted to the special requirements.

UV screen printing inks cure by chemical reaction initiated by UV-energy. Basically correlations between three factors should be considered:

1. Energy requirement of the ink.
2. Maximum energy of the drier at minimum belt speed.
3. Actual energy available at production speed.

1. Energy requirement of the ink:

There are UV ink types for various applications exhibiting various properties. Depending on the binder system required for the application UV, inks show quick, slower or even especially slow reactions to UV radiation. Highly reactive inks require low UV energy for curing, while systems with a very low reactivity require up to 30 times more energy.

...CURING

This UV energy can be measured with a so-called UV-integrator. The value is measured in Millijoule per square centimetre (mJ/cm^2). However devices of different manufacturers show different values.

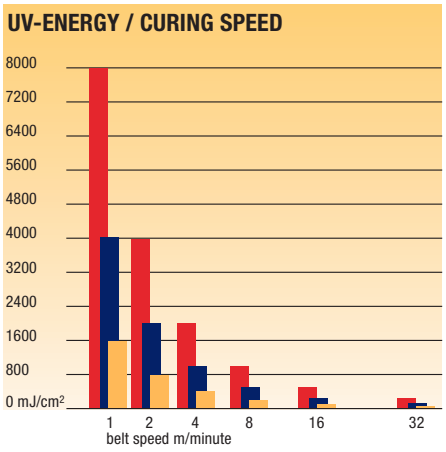
The amount of UV-energy required may vary to a large extent depending on the ink system (measurement values are based on the Kühnast UV-integrator).

In numbers:
Highly reactive inks for paper and common plastics such as PVC, PS or PP (pre-treated) require between 100 and 350 mJ/cm^2 (Coates MLS, UVE, UVPO, UVN).

Inks for PMMA, PC or coated surfaces with higher resistances, e.g. for technical applications, require between 350 and 1.000 mJ/cm^2 (UVP).

For decoration of metals or glass, inks with quite a high energy requirement are processed. Depending on applications energy requirement is between 1.000 and 3.000 mJ/cm^2 (UVK, UVGL).

ENERGY REQUIREMENT OF UV-INK TYPES	
Ink A > Paper / PVC / PC:	100 - 200 mJ/cm^2
Ink B > PVC / PS / PP:	200 - 350 mJ/cm^2
Ink C > PC / PMMA:	350 - 500 mJ/cm^2
Ink D > coated metals:	500 - 1000 mJ/cm^2
Ink E > metals, glass:	1000 - 3000 mJ/cm^2



The relation of energy amount and the belt speed is inversely proportional. If speed is doubled efficiency will be half. The higher the initial efficiency the quicker you can cure.

2. Maximum energy of drier at minimum belt speed.

Power of UV-driers is indicated by number of UV-radiators/lamps and their electric efficiency in W/cm. The actual amount of UV-energy available for curing of the ink, however, depends on the size of the UV-share emitted in the energy spectrum of the lamp (this will become lower when the lamp gets older), the distance between lamp and substrate as well as on the speed used to transport the printed sheets under the lamp(s).

In case the energy efficiency of the drier is lower than the energy requirement of the ink, the drier will be insufficient for curing. If the energy efficiency is higher, production speed can be evaluated.

3. Actual energy available in production speed.

Printing format (+distance of sheets) and printing speed require a minimum belt speed of the UV-drier. If at such speed the energy requirement of the ink is met, everything is ok. If there is more energy than required, energy can be reduced by increasing the belt speed. If energy is too low, production or belt speed has to be reduced to a sufficient energy level. Here relation of energy amount and the belt speed is inversely proportional. If speed is doubled, efficiency will be half and vice versa.

When purchasing a UV-drier one should choose equipment supplying sufficient energy for the inks and production speeds used. In that respect efficiency loss of aging lamps should be considered as well.

Examples:

PVC-INK, ENERGY REQUIREMENT FOR CURING AT APPROX. 200 MJ/CM²

UV drier A
efficiency at 1 m/min. = 2.000 mJ/cm^2
maximum belt speed possible is only 10 m/min.
(approx. 800 prints/hour in format 100 x 70 cm)

UV drier B
efficiency at 1 m/min. = 6.000 mJ/cm^2
maximum belt speed possible is 30 m/min.
(approx. 2.200 prints/hour in format 100 x 70 cm)

Prior to purchasing a UV-drier equipment, one should therefore evaluate various basic data to equip the drier according to the print shop's individual requirements.

Among others the following questions should be considered:

- *Types of **substrates** to be printed?*
- Energy ***requirement*** *of the UV-inks used?*
- ***Formats*** *and* ***printing speeds****?*
- *Are the substrates **sensitive to heat**?*
- *Where will the UV-drier be **installed**?*

If you have answers to all these questions, efficiency data of the UV-drier can be determined.

...CURING

Substrates, energy requirement, printing format and printing speed

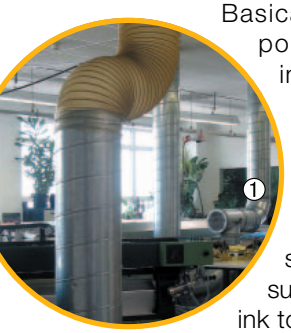
As already mentioned, there are UV-ink types with various properties for numerous applications, which naturally also have different energy requirements.

Ink type used, printing format and printing speed will therefore determine the required energy capacity of the UV-drier.

Thermal influences on the substrate:

Quite a considerable part of the energy spectrum of the UV-lamp is infrared-radiation (IR). Operation temperature of the lamp is approx. 900 °C. The IR-amount emitted by this lamp is led off by cooling systems, mostly exhaust air systems. When working with extremely heat sensitive substrates, reduction of IR-radiation is especially important.

Installation of the UV-drier:



Basically there are various possibilities of UV-drier installation. Either individual units set up next to a printing line or driers integrated into a printing line in combination with a circulating oven. In some cases it may be suitable to allow the printed ink to cool off for some time. Such cooling off times are sufficient if, for instance, the UV-equipment is installed at the beginning or in the mid of the circulating oven. Sufficiently cured UV-inks do not block in the rack. Certain systems, such as e.g. inks suitable for deep drawing applications, contain binders with quite a low softening point. Thus they may tend to block in the rack if the residual heat is too high.

Another important factor influencing curing of a UV-ink is the construction of the reflector at the radiator. UV-driers for screen printing applications are often equipped with radiators with a more or less strong focussing, however, there are also constructions without focussing. Focussing reflectors beam the UV-energy to a small area below the longitudinal axis of the lamp thus transferring concentrated UV-energy in a short distance. This again means that the materials are subjected to more heat. Non-focussing systems scatter the UV-light over a broad area thus reducing the heat applied to the substrate. Inks with a high energy requirement, e.g. dark glass inks, however will then not sufficiently cure. Even though the UV-measuring device will show sufficient values, the energy distribution over a large area will prevent complete curing of the ink.

NECESSARY CONSIDERATIONS FOR DAILY PRODUCTION WORKS

Fine Adjustment of Ink Curing:

Colour shades /Colour mixtures:

Basically the ink manufacturer tries to adjust the various colour shades of an ink range so that they show approximately the same energy requirement. If the screen printer mixes colour shades, the energy requirement of such mixtures may be different. Opaque, dark shades (e.g. medium or dark grey) with a high content of white or opaque white will require higher curing energies, whereas shades with a high content of clear varnish will require a little less curing energy than e.g. standard colour shades.

Overprintability:

Most UV-ink types show good overprintability properties in multi-layer printing. Due to the various influences the UV-drier has on curing (lamp status, reflector, cooling), overprintability of inks is evaluated during the printing process. It is possible that the energy values require adjustment for the individual colours, e.g. first colour lower curing range, followed by step-by-step increase of these values. Furthermore, UV-ink systems show good overprintability within periods ranging form several hours to a couple of days. When interrupting the printing process, e.g. for the weekend, it is necessary to check whether the ink system used has a sufficient overprintability range under the local printing conditions.

Overcuring:

In most cases there won't be a direct negative influence on ink and ink adhesion if the recommended curing energy is significantly exceeded, however overprintability may be affected.

Insufficient curing:

If curing energy is too low there will be increasing problems depending on the degree of insufficient curing. Adhesion will be reduced, ink surface will become sensitive (scratch resistance), colour shade may be spotty and prints will also not be stackproof.

However, such insufficient curing may not show until the printed product has reached the end user – there will be an unpleasant, disturbing smell due to insufficiently cross-linked monomers of the ink. In sensitive sectors, such as food or medical industries insufficiently cured inks may lead to serious problems. In such cases safety regulations are not met, as the ink film may release non cross-linked ink components.

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CONTROL OF LAMP STATUS:

Aging of the UV-lamp:

Increasing age of UV-lamps will lead to a significant reduction of their UV-emission. If work is continued using these belt speeds evaluated using the new lamp without further control, sooner or later there will be the problem of insufficient curing and its known risks.

Decrease of UV-emission of lamps must be corrected by reduction of belt speed. Typical signs of aging of a lamp are e.g. increasing blackening of the ends of the bulb as well as whitening of the glass.

Contamination:

In operation dust particles get into the drier. During the curing process components evaporate from the ink layer, which possibly may form deposits on the lamps and reflectors. Such deposits must not be underestimated as they may cause up to 30% efficiency reduction of the equipment.

Regular control and cleaning (free of grease, with alcohol) of lamp and reflector will help to avoid these problems.

① Cooling system:
Effective cooling systems have a big exhaust air stream. The hot air should be led to the outside the shortest way possible.

② Cleaning of lamps and reflector: Deposits may reduce UV-emission up to 30%

③ Aging of lamps: Blackened ends of bulb and white spots on the glass are typical signs of lamp aging.

④ Also for UV inks: standard test of adhesion and scratch resistance by finger nail tape and cross hatch test.

⑤ Evaluation of drier adjustments upon start of production:
UV-integrator is sent through the drier.

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UV screen printers surely would like to have an inexpensive measuring device, similar to a densitometer, which could measure degree of curing by simply putting it onto the printed ink film. Such an appliance won't be available for some time. Measuring and testing can be done by two different methods. On to one hand the common methods screen printers use, cross hatch test, fingernail test and on the other hand the corresponding physical and chemical tests according to test specifications. Chemical analysis in special laboratories is required to determine specific safety regulations of curing degree, content of residual monomers, e.g. printed articles for the food industry, toys and medical appliances. If these test results are okay the screen printer has to make sure that production is carried out with the same curing parameter than the tested parts. Here again it is essential to use the UV integrator to measure the UV energy that reaches the printed parts.

In conclusion we can say that when printing with UV inks a little more attention is required to the curing process and control of the curing equipment than to the printing process itself. UV inks hardly dry in, change colours and the like, however curing parameters are of utmost importance.

The main key to success is to choose UV-equipment adjusted to the individual requirements of screen printers. Then strengths of UV-inks can be optimally taken advantage of in production process.

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...MEASUREMENT & TESTING