Martin Kremmeter
Laboratory:
UV Ink Systems

THE INFLUENCE OF UV-CURING ON RESULTING PRINTS

UV technology and use of UV curing printing inks have more and more penetrated the whole printing market during the last couple of years. The possibility to cure printed inks within seconds is especially important for quick running printing equipment from roll to roll or for large numbers of prints. Printers can significantly increase their lot sizes with UV inks. These days you can find growing numbers of UV-products in the field of offset and flexographic printing.

UV technology has another important advantage for screen printers: unlimited screen stability. The ink does not dry in the screen so that even finest details are printed during the whole printing cycle; an important feature for process prints and in case of standstill times of multi-colour printing equipments.

Printers have to pay extra attention to various issues when processing UV curing screen inks. Often curing these types of inks in a UV-drier is a still unknown factor of the printing process.

Printers are often confronted with the question, whether the printed ink is sufficiently cured. Insufficient curing has a vital influence on end properties such as adhesion, gloss and chemical resistance.

In our daily laboratory work we often face the problem that the results of the print run do not match the results of the first printing trials, even though ink and material were the same. We often find that different UV-driers were used for tests and print run and that is the cause of such problems.

To explain this problem in more detail we first have to describe the theory of UV-curing.

WHAT HAPPENS DURING UV CURING?

Chemically, curing of UV-curing screen inks is a radical polymerisation. In simple words small and medium-sized molecules (monomers and oligomers) form larger parts by chain reaction. If the substances used can only grow on one section – these are 1-functional monomers and oligomers - linear chains are formed. Cured ink films then have similar properties like 1-component solvent based inks. They are quite flexible, can be thermoformed and show little chemical resistance. Raw materials which grow at two or more sections (multifunctional monomers and oligomers) result in more or less cross-linked networks. The resulting UV prints are of low flexibility or even become brittle like glass, show bad forming properties but good chemical resistance. In a broader sense, such inks can be compared to 2-component solvent based inks.

The whole trick of UV ink development is to combine all available raw materials in such a manner that the ink meets all required end properties.

Taking a closer look at the curing process the real starters of the reaction are the photoinitiators contained in the UV ink. Under the influence of UV light they break and form radicals. These radicals react with the reactive centres (so-called double bonds) of the monomers and oligomers. During that process the double bonds open and release the radical. That way a continuously growing chain or a constantly growing network is formed.

During the process the initially liquid ink thickens. At a certain point the reaction will stop because of lacking mobility. The radicals and double bonds cannot connect anymore and become stationary. The ink solidifies. That cured ink still has reactive double bonds which, however, are immobile and cannot react anymore. Only approximately 70-80% of the double bonds contained can be transformed if UV-inks are optimally cured.

For the sake of completeness we would like to point out that in addition to radical there is also the type of cationic polymerisation. Instead of double bonds and radicals cationic polymerisation is set off by epoxy groups and acids.

EFFECTS ON THE CURED INK FILM

To obtain optimal end properties of a UV-ink it is necessary to obtain reactions of as many double bonds as possible. This is best accomplished if the required UV-light is directed to the ink in one go to initiate the reaction. If UV-light is insufficient not enough of the double bonds are transformed and the ink will not show the required end properties. There is also little reaction if an ink, which has already been pre-cured is subjected to UV light again, as the reactive groups are now immobile.

Figuratively speaking when playing "try your strength" it does make a big difference if you use three light hammer strokes instead of making a triple-strength single blow.

MEASUREMENT OF UV-ENERGY

To ensure proper processing of UV-curing screen printing inks it is crucial to constantly control the UV-driers. Best possible control of conveyer driers is done using UV-integrators. These generally are flat discs which are passed under the UV lamp using a conveyer belt. The UV light transmitted within a certain wavelength is measured by means of a photo cell. Lamp efficiency is then indicated in mJ/cm^2.

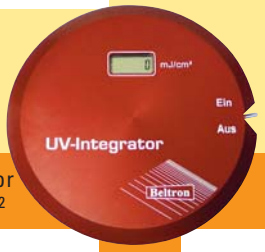
Actually this value in mJ/cm^2, however, only applies to the UV-drier the measurement was taken in as well as the belt speed used in combination with the UV-integrator used for the measurement. There are big differences in the construction of various makes of driers and UV-integrators.

In addition to different UV lamps used in UV-driers (100 W/cm or 120 W/cm) there is also a variety of reflector constructions. Some systems reflect the UV-light the lamps emit to the top in a broad range to the bottom. These are so-called non-focussed or diffuse reflectors. Better curing results are obtained with focussed reflector systems as the UV light beam is directed to one or two points. There are peaks of efficiency with an extremely high amount of UV light used to cure the UV ink which initiates optimal polymerisation.

Thus an ink will cure in one UV-drier using a focussed reflector at a certain amount of mJ/cm² whereas the same ink won't cure in another UV-drier using non-focussed reflectors. The values of the UV-integrator will not give information on the efficiency peaks of the UV lamps. Generally powerful radiators will achieve much better curing results of ink films than less powerful radiators.

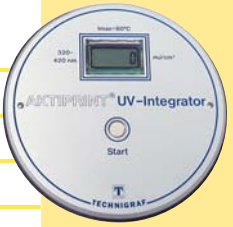
Also caution is required when comparing measuring values of integrators made by different suppliers. There is no standard and every manufacturer uses different measuring systems. The table below shows the differences of three well-known manufacturers. This chart can also be used as a guide if you want to compare your measuring values with those of other suppliers. Coates Screen Inks GmbH is using Kühnast UV integrators. This should not be considered as a rating as all three UV integrators are excellent and are commonly used.

COMPARISON MEASUREMENTS WITH VARIOUS UV-INTEGRATORS

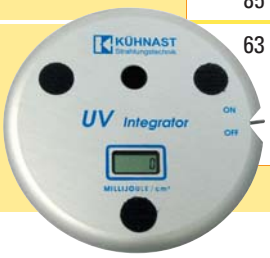


Manufacturer UV-Integrator
Measuring value in mJ/cm²

Belt speed m/ min	KÜHNAST	BELTRON	TECHNIGRAF
5	518	1083	1330
10	253	517	646
20	130	280	335
30	85	186	222
40	63	135	164



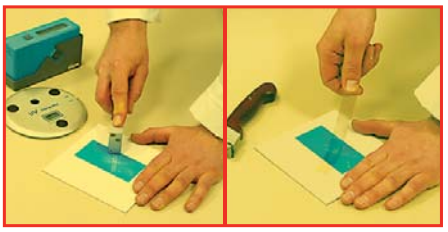
* Drier Technigraf
1 lamp 120 W/cm



*

The values listed in above chart show a significant difference of the mJ/cm² values of the various UV-integrators, partially the values are doubled. This clearly shows how important it is to name the UV-integrator used when comparing individual measuring results.

If you want to use a certain UV ink for a printing job, it is essential to check the product data sheet for information about the required UV energy as there are many different UV-ink systems with different energy requirements. Considering above chart that mJ/cm² value should be transferred to the individual UV-integrator used. Printing trials on original material using corresponding UV-energy and belt speeds should be made to evaluate suitability of the ink.



Printers will have to use the known test methods like fingernail and cross hatch adhesion tests to evaluate sufficient curing and adhesion of an ink. If the ink film has a sufficient polymerisation these tests will show sufficient hardness, good adhesion and scratch resistances. If an ink is still soft like wax curing was insufficient. That may happen with opaque shades.

Finally we would like to point out that the control of UV-driers with a measuring device such as a UV-integrator is essential. That is the only way to detect a decrease of efficiency caused by weak lamps or contamination of reflectors. Measuring values of integrators of various manufacturers cannot be compared and must be conversed to the type used. The curing parameter set up should be controlled during a print run to control curing of UV-inks thus optimally taking advantage of the strengths of UV-technology.

Martin Kremmeter
+49 911 64 22-277 +49 911 64 22-283
martin.kremmeter@sunchemical.com