Thermofuse Digital Plate Technology

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Keywords : Offset, CTP, Thermal, Development, Environmental

Abstract : Thermofuse is a totally new approach to digital printing plate technology, conceived and developed by Agfa.

The imaging mechanism is based on thermal coalescence of sub-micron latex particles, a purely physical process. Thermofuse enables chemistry-free and truly processless digital platemaking, while offering printing plate properties very similar to today's currently used products. Because of the physical nature of the image creation, and the elimination of the variables inherent to chemical plate processing, Thermofuse technology is a powerful basis for new convenient, high performance printing plate products.

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Introduction

Since the introduction of thermal computer-to-plate about 10 years ago, an important evolution in thermal digital plate technology has been taking place.

In what can be considered the first generation of thermal computer-to-plate technology, acid catalyzed crosslinking was used, whereby an acid was formed imagewise upon exposure with an 830nm laser.
The released acid enables in a thermal step (so called pre-heat, at approx. 140°C) the thermal crosslinking of novolac based coatings, the acid acting as a crosslinking catalyst.
In the unexposed (uncatalyzed) parts, the hardening is not initiated.
In a second processing step, the unexposed parts are developed in an alkaline developing solution. Hereafter a rinsing step is added and finally a protective gum is applied.
Additionally, high temperature baking for very high runlengths is an option.

In a second generation of thermal plates that has come to the market, the preheat step is eliminated.
Novolac based coatings undergo a physical transformation upon thermal exposure, whereby the solubility of the coating is increased by the thermal energy absorbed during exposure.
In the developing step that folllows, the exposed areas are selectively dissolved in an alkaline developing solution.
Hereafter a rinsing step is used and finally a protective gum is applied.
Optional high temperature baking allows for very high run lengths.

Beyond this second generation technology, the evolution towards more convenient processing, chemistry free and/or processless plate systems is becoming more and more a reality.

Ablative plate systems whereby e.g. a thin hydrophilic top layer is ablated by thermal exposure have had rather limited success until today.
Two important drawbacks related to ablative technology are a) the need for an ablation removal system which evacuates ablative debris and/or fumes, to avoid contamination of optics during exposure (but also for ecological and health & safety reasons), and b) less favourable printing characteristics.
Printing characteristics are usually inferior because these materials do not print from a grained and anodised aluminum substrate but from a hydrophilic layer having narrower press latitude.
In most cases, unless exposure energy is very high (low throughput), additional wash or rinsing is needed to remove all the ablated material before going on press.

So called switchable polymer or switchable surface coatings consist another technology already widely described in literature and patents.

With these technologies, a transition from hydrophilic to oleophilic or vice versa is made at the surface of the coated layer upon exposure. These layers combine both hydrophilic and oleophilic functions into one layer instead of the usual two layers with separate functions.

Also here, printing is not from a hydrophilic anodised aluminium substrate, but from a hydrophilic coating which also acts as the ink accepting medium upon switching.

This approach allows printing directly after imaging, without any additional step inbetween exposure and press start, i.e. truly processless plate systems.

However, significant challenges still need to be overcome.

To obtain enough lithographic differentiation, and to get very hydrophilic and very oleophilic areas on the coating surface, is one serious challenge. To keep this differentiation over higher run lengths is another.

It is expected that the time needed for this technology to mature into a wider commercial application will take at least another few years, if ever…

Agfa developed the Thermofuse technology because it recognized this to be the most promising technology beyond the second generation thermal plates.

Thermofuse technology enables the development of digital thermal plates with more convenient processing, and also of chemistry free and/or processless plate systems. It makes use of grained and anodised aluminium substrate to ensure optimum press performance and latitude.

The Thermofuse technology

Thermofuse is a new approach to digital plate technology, based on latex coalescence. Upon thermal exposure, thermoplastic particles are fused and melted onto the aluminium substrate. It is an Agfa patented technology *(1, 2).*

The working mechanism is presented in figure 1.

The Thermofuse active layer, coated from aqueous medium (other thermal plates are coated from solvent medium), exists of mainly very fine thermoplastic polymeric particles.

An unexposed coating is visualised (SEM) in figure 2, clearly showing the individual polymeric particles held together by a stabilising binder to avoid fusing before thermal exposure, i.e. ensuring good shelf-life. The coating is stable for longer time even at higher temperature (storage > two weeks at 50°C).

Change of coating by exposure is visualised in figure 3 (SEM image) and a cross-sectional view of an exposed part of coating is visualised (SEM) in figure 4, showing that the polymeric particles are fused after thermal exposure.

The particles are specifically designed to formulate coatings with sufficient exposure sensitivity, and to obtain coating surfaces after exposure with fast inking up characteristics and good resistance towards press chemicals.

The outstanding resistance to press chemicals is controlled by the chemical composition of the polymeric particles. The size of the particles controls the sensitivity, i.e. the smaller the particles the better the sensitivity (the lower the energy required for imaging), see results in table 1.

With particle sizes of 77nm, the required energy for proper fusing (criterium is rendering of 2% dot @ 200lpi screen, smooth substrate) is 190 mJ/cm², while for particle sizes of 50nm the same fusing is achieved at an exposure of 150 mJ/cm².

Table 1 : sensitivity vs particle size

Particle size (nm)	Sensitivity (mJ/cm²)
77	190
61	170
50	150
36	120

The coating design also enables proper clean out of the unexposed areas when brought in contact with specific liquids. Several cleanout concepts are possible.

Cleanout on press can be made using the already available fountain and ink. The unexposed coating is then removed upon press start, and the plate acts as a processless plate. This is the case with Agfa's Thermolite™ plate.

In the :Azura thermal plate system the gum is acting as the liquid ensuring proper clean-out of the unexposed areas as well as suitable conservation, while the gum also protects the substrate.

In a third concept, a mild developer can be used with Thermofuse plates in regular processors as used for thermal plates, enabling the use of this technology as a general purpose thermal plate with superior processing latitude (as compared to existing thermal plates) and extremely long bath-life.

Aluminium substrate for Thermofuse technology

In the offset printing industry, approx. 90% of printing plates are based on a grained and anodised aluminium substrate.

The use of these substrates as a standard is because of

- the attractive mechanical properties of aluminium, e.g. its strength and ability for bending, needed for the high quality work and plate handling on printing presses
- the high quality printing performance achieved with a grained and anodised aluminium surface, e.g. high run length, printing latitude, scratch resistance,… .

In the graining phase, the aluminium surface is roughened, and a well defined topography is achieved. Electrochemical graining has become the predominant graining process, since a better control of the topography is possible than by mechanical graining (e.g. via abrasive powder with brushes).
After graining, a typical roughness is 0.2 – 0.6 µm (measured mechanically as CLA or with interferometer); smooth versus rough substrate topographies are shown in figures 5.

After graining, the soft aluminium surface is anodised to improve hardness of the surface and to optimise plate performance e.g. hydrophilicity, stain, run length *(3, 4)*.
As will be explained below, a suitable anodisation layer is about 1 µm thick as can be seen from figure 6.

Additionally, in a post anodic treatment, a thin (~10 nm) layer is applied to optimise the plate characteristics, e.g. adhesion of the active coating, or to optimise clean out of the hydrophilic surface in the non-image areas (complete removal of active layer).
Examples of post anodic treatments are treatment with hydrophilic polymer (e.g. Polyvinylphosphonic acid), Zirconium salts or silicates.

For Thermofuse technology, a homogeneous smooth grained and anodised substrate is used.
The smooth substrate is well designed to offer improved image quality, i.e. dot reproduction and to improve adhesion to the substrate for achieving higher run lengths.
The dot quality improvement by smooth substrate is demonstrated in figure 5.
On a smooth substrate (figure 5a) dots are better defined and sharper than on regular substrates with higher roughness (figure 5b).
The effect of substrate roughness and anodisation on plate characterisctics of the Agfa :Azura plate are shown in figures 7-11. :Azura is a chemistry free plate based on Thermofuse technology, which uses a gum cleaning step after imaging, and which is explained later in this paper.

The roughness, obtained by chloric acid graining, was varied and the effect on run length is pictured in figures 7-10.
In figure 7, a 40% dot (200lpi) reproduction on print is shown during a print run of 50,000 copies, for a substrate CLA=0,53µm and for a smooth substrate (CLA=0,25 µm).
On the smooth substrate the 40% dot is printed very stable while on the rough substrate dot wear is already clearly visible at 30-50,000.
The effect of roughness on run length is shown in figure 8. Lower CLA improves run length substantially, until the optimum level is reached. Further lowering roughness again gives worse results. In these conditions a homogeneous surface with high specific surface is no longer obtained.

These results indicate that roughness needs to be tuned carefully to obtain optimum plate performance.
Within the workable area (0,2 – 0,55 µm), comparative run length tests on more critical images (20 µm dots) were carried out and are presented in figure 9; anodic weights are 3,8 g/m². This clearly confirms that certainly for high quality images the smooth substrate ensures a higher run length.

Also the effect of anodic weight (for CLA=0,25) is demonstrated (figure 10). This parameter has a smaller effect on run length, but the higher the anodic weight, the higher the run length.

Also sensitivity is affected by the substrate characteristics.
A uniformly smoothly grained substrate with high specific surface guarantees efficient adhesion upon exposure, and hence contributes to a higher sensitivity, i.e. less energy is needed to fuse exposed areas onto the substrate.
This is more beneficial for very small dots, e.g. single pixels, whereby the edge effect is more pronounced.
This is clearly demonstrated by the results shown in figure 11.
For a substrate having a CLA=0,53 µm, an 8x8 checkerboard is rendered in print when exposed at 175 mJ/cm², and a 1x1 checkerboard needs an exposure of 225 mJ/cm² to get fully rendered in print.
On a uniformly smoothly grained substrate (CLA=0,21) an 8x8 checkerboard is rendered in print when exposed at 150 mJ/cm² and a 1x1 checkerboard is fully rendered in print at an exposure of 190 mJ/cm².
On the smooth substrate a 2% dot of a 200lpi screen is fully rendered at 190 mJ/cm² while 225-250 mJ/cm² is needed on the substrate having a CLA=0,53 µm.

When run length tests are carried out for various exposure levels, the smooth substrate is demonstrated to be substantially better for sensitivity as well as absolute run length, as can be concluded from results shown in figure 12.
At the start of printing 2% dots (200lpi) are rendered well.
On the smooth substrate, at exposure levels of 215 mJ/cm² or higher, 2% dots of a 200lpi screen are rendered for the full run length of 30,000 sheets.
At the same exposure level (215 mJ/cm²), on the CLA=0,53 µm substrate, the 2% dot wear is already substantial after 10-15,000 sheets, after 20,000 sheets the smallest dot rendered is 6% dot and after 25,000 sheets only 8-10% dots are still visible (note that dots are reduced in size, so real coverage is lower than the nominal value).

Thermofuse product(s) :Azura

Thermofuse technology might make existing digital plate technologies obsolete in several ways, because it dramatically reduces processing complexity, and relieves the user from much of the attention and care about processing conditions. But also handling, storage, and treatment of chemicals (e.g. press chemicals) are strongly affected in a positive sense.

The application of Thermofuse technology in the :Azura plate has resulted in a convenient yet performant new plate system.
After (thermal laser) imaging, the plate is cleaned and gummed in one single step, in a dedicated :Azura cleaning unit. A dedicated plate gum is used (in batch mode – until pre-defined contamination level). No fixed water supply is needed, as no water is used for cleanout. No temperature control is needed, and no control of chemistry condition, since no chemical reaction takes place. There are no user adjustable controls. All this greatly reduces system care and maintenance for the operator.

The main characteristics of :Azura are :

- chemistry free, negative working, 830 nm sensitive plate material
- non ablative, purely physical imaging mechanism
- printing from a high quality aluminium substrate
- aqueous plate coating, aqueous plate gum for environmentally friendly plate making
- gum use of 67 ml/m²
- 100K run length, typically
- good image contrast on plate

:Azura represents the 2nd product that Agfa introduces, based on Thermofuse (after :Thermolite, introduced in 2000 for use on digital offset presses).
A typical :Azura based platemaking system is shown in figure 13.

From a plate manufacturing point of view, no solvents are needed. The coating is made from aqueous medium, and hence is not impacting the environment.

From a plate making point of view, the coating is sensitised for state of the art laser imagers, e.g. 800-850nm lasers, but also other sensitisation is possible.

Wit respect to energy requirement : typically, :Azura needs higher exposure energy than negative plates based on chemical reactions and need for preheat, (where part of the required energy is applied in a preheat step). On the other hand, it can be expected that Thermofuse technology will be able to take advantage of higher laser power available in the future.

Conclusion

Agfa’s Thermofuse technology has proven to be capable of eliminating plate processing variables, hereby substantially reducing processor maintenance and cleaning, enabling downsizing equipment and lower space requirements (figure 14). On top, this technology offers a chemistry-free CtP workflow (:Azura) and even processless platemaking (Thermolite), be it limited to on-press imaging applications. These characteristics make the technology also operator and environmentally friendly.

Agfa has made important efforts to optimize the Thermofuse coating and aluminium substrate characteristics, as explained in the foregoing.

With respect to print quality and latitude, Thermofuse prints from a high quality, well designed grained and anodised aluminium substrate and hence, is at least as good as conventional (developer based) CtP (or analogue plates). Thermofuse based plates are also highly resistant to press chemicals.

It is our belief that with Thermofuse, Agfa has made an important step forward in the direction of more convenient, high performant, ecologically safe offset platemaking.

Figure 1 : Working mechanism of Thermofuse technology (latex coalescence)

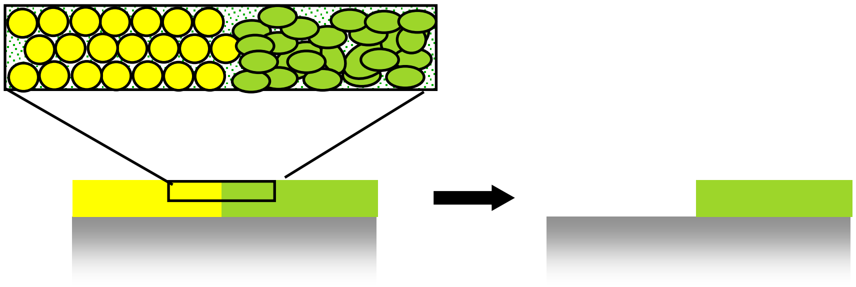


Figure 2 : Unexposed :Azura coating (SEM image cross sectional)

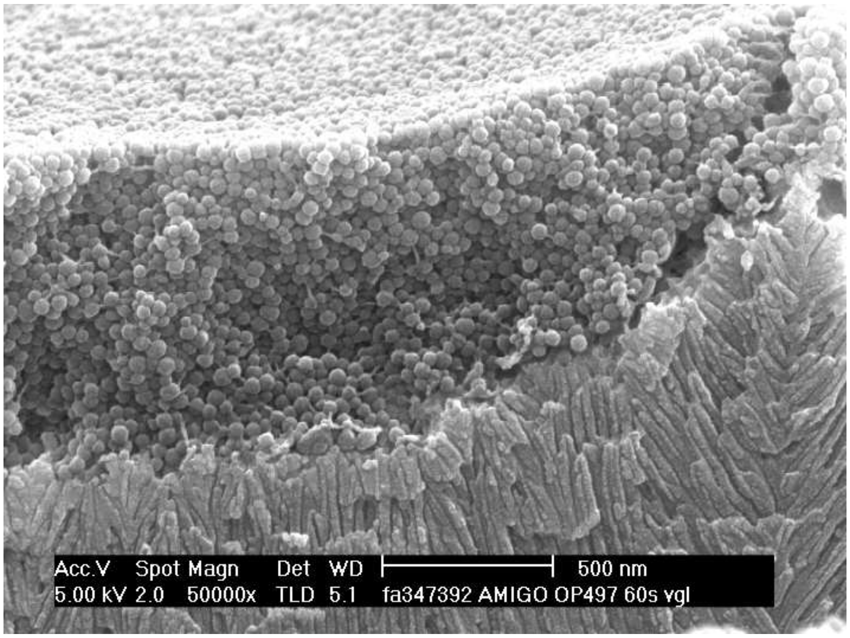


Figure 3 : SEM image of exposed and unexposed areas in :Azura plate

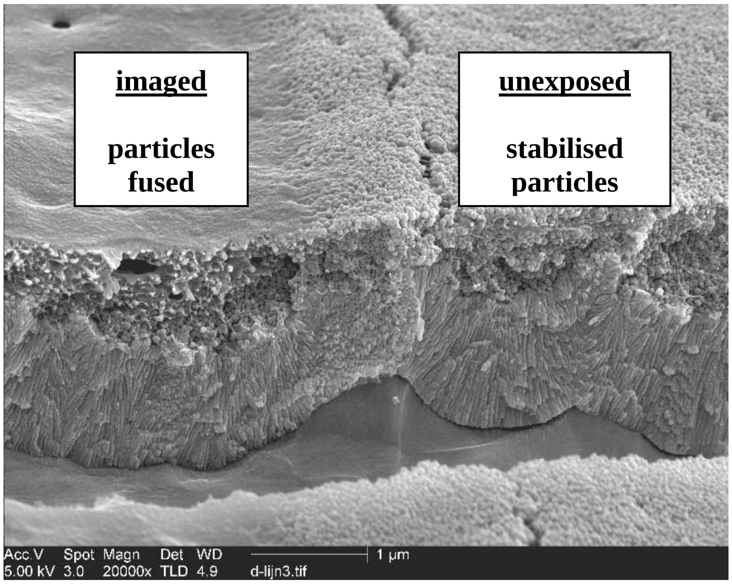


Figure 4 : SEM image (cross sectional) of exposed areas in :Azura plate

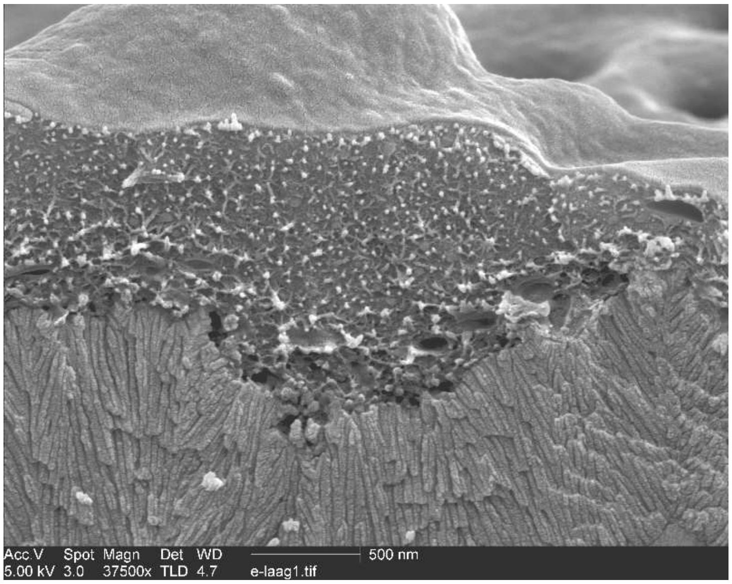


Figure 5a : dot reproduction of 2x2 checkerboard on smooth substrate (CLA=0.25µm)

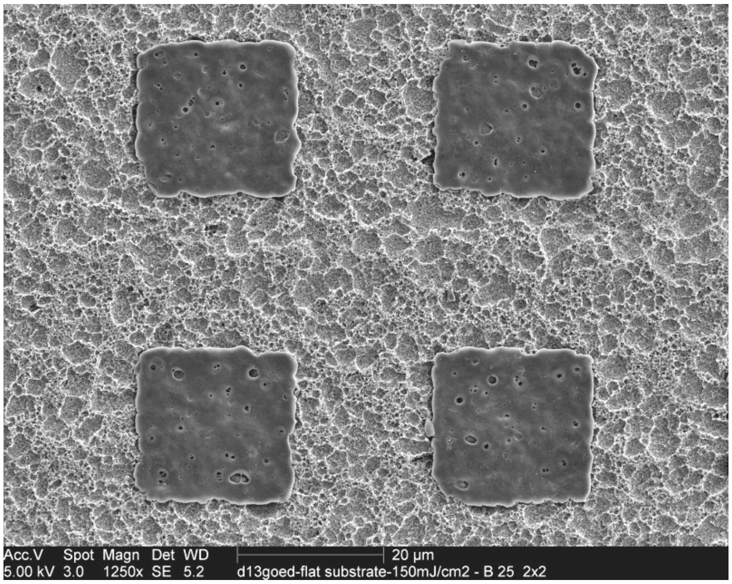


Figure 5b : dot reproduction of 2x2 checkerboard on smooth substrate (CLA=0.53µm)

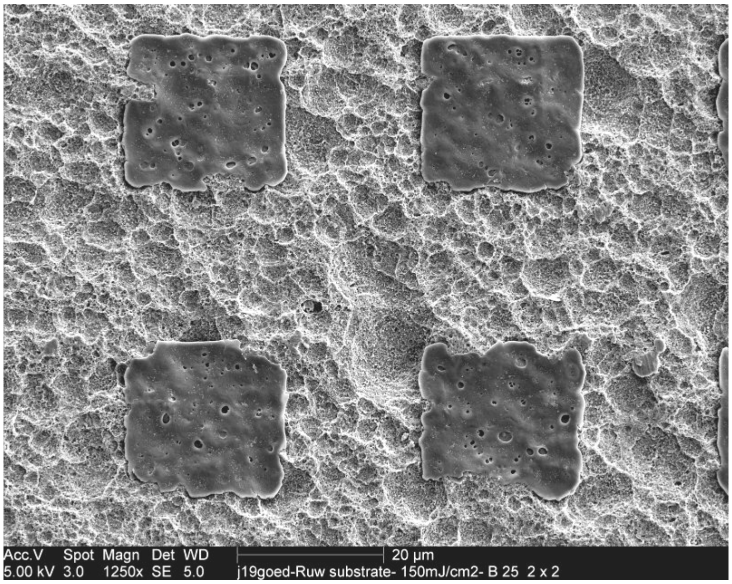


Figure 6 : Typical anodic structure on top of a grained aluminium

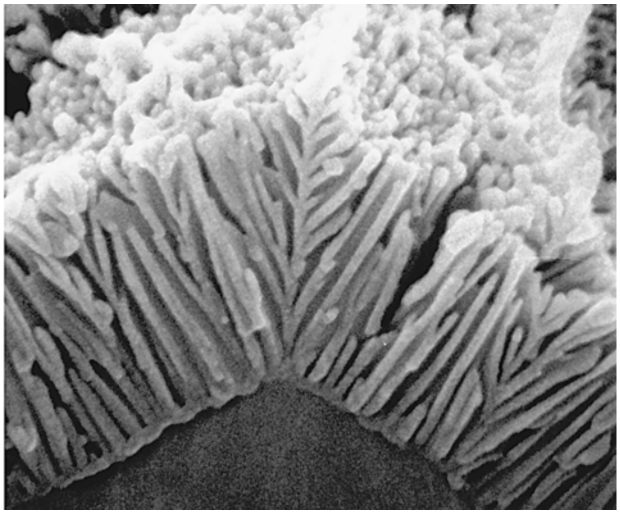


Figure 7 : Dot rendering (40% screen 200pli) evolution during printing

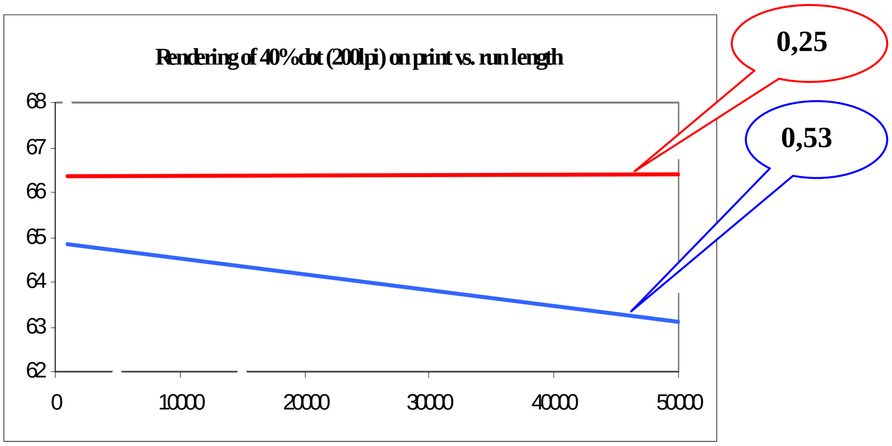


Figure 8 : Effect of roughness (chloric acid graining) on run length

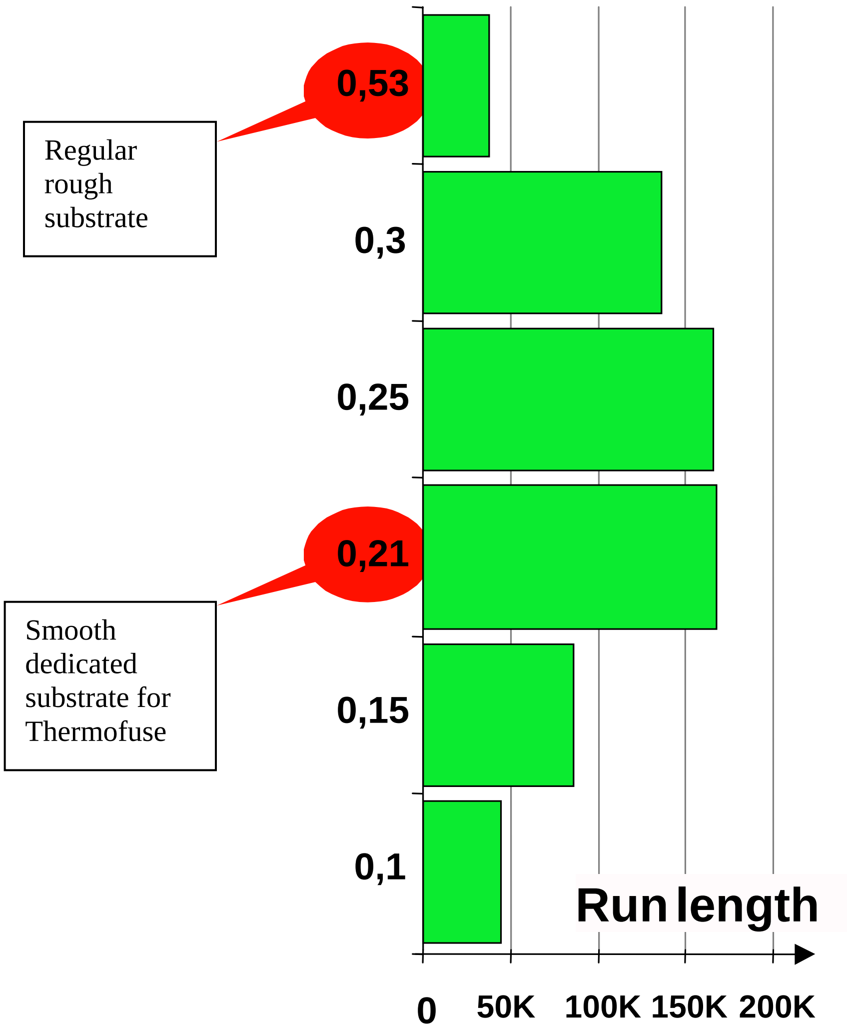


Figure 9 : Effect of roughness on run length of high quality prints (20µm dots)

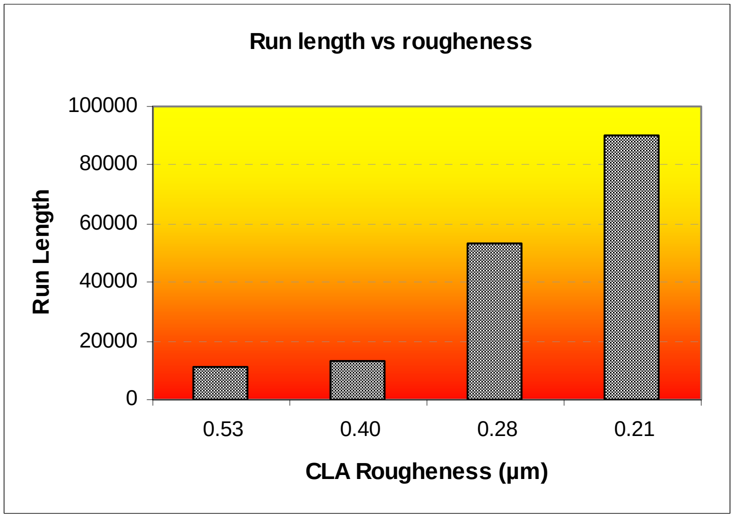


Figure 10 : Effect of anodic weight on run length of high quality prints (20µm dots)

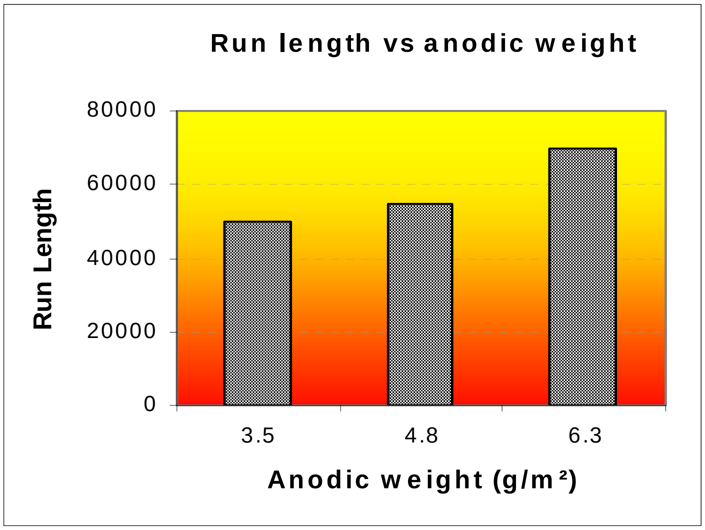


Figure 11 : Checkerboard rendering (on print) for various exposure levels

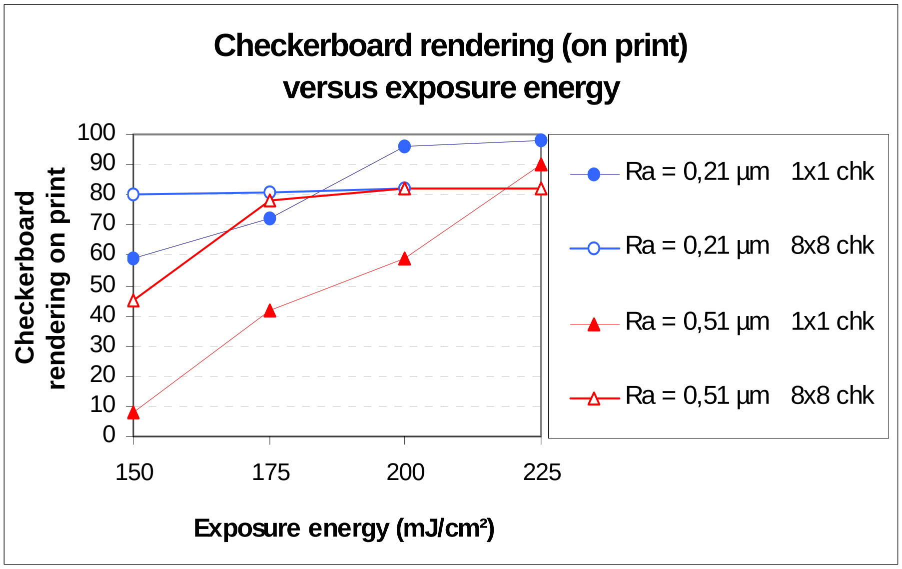
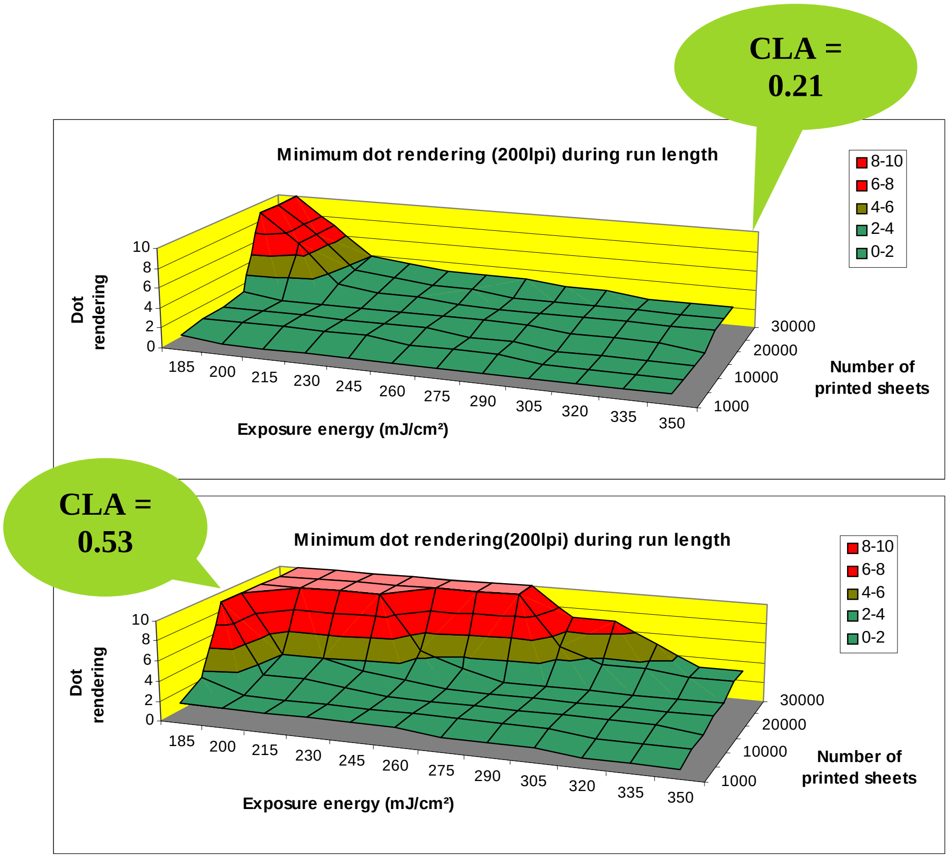


Figure 12 : Dot wear for various exposures with rough and smooth substrate



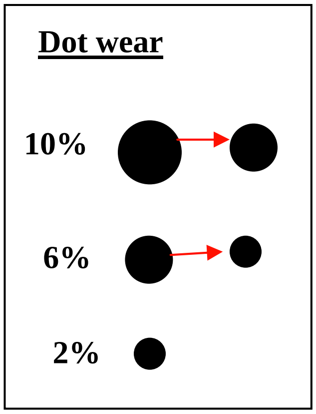


Figure 13 : Typical :Azura based platemaking system

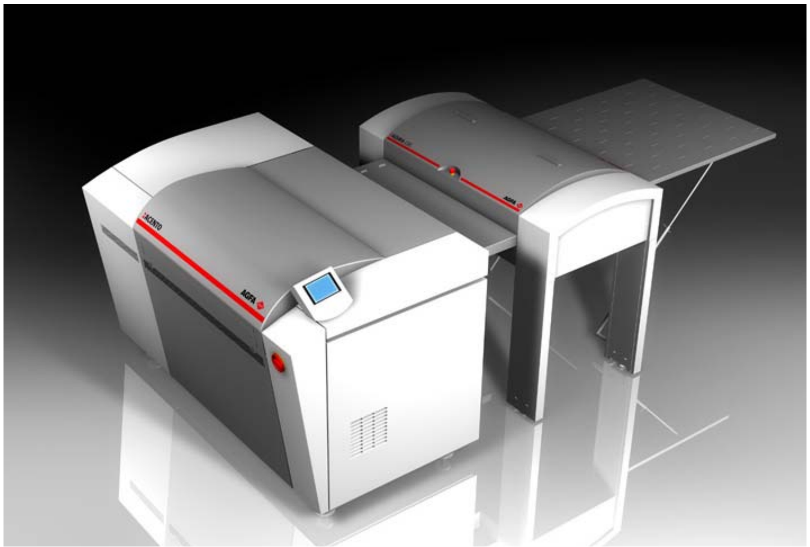
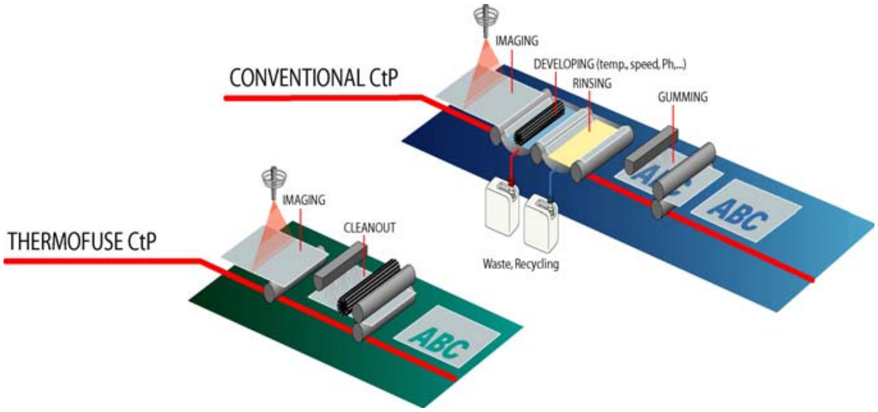


Figure 14 : Schematic representation of Thermofuse (:Azura) workflow versus conventional thermal CtP workflow



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