The Future Potential of the Cast Coating Process

Gerd Papier, Andre Becker, and Olaf Friederichs
Zanders Feinpapiere AG
Bergisch Gladbach, Germany

Abstract

Today, fotolike glossy inkjet papers are produced according to different production methods. One method has been derived from silver halide foto paper technology and uses PE layers to achieve the high gloss. The other one is based on the cast coating process, which produces high gloss by pressing the water based coating color on to an extremely smooth chromium drum.

At the beginning of the development of glossy inkjet papers these products have been the smooth base for an additional overcoat, which introduced the inkjet capability.

Later on, the inkjet suitability was transfered directly into the cast coating layer, so that the additional layer becomes obsolete. This allowed for having a porous and glossy surface and the ink uptake can be managed by porosity and not by the time consuming swelling of a polymer.

For now, this technology is successfully applied and easily competes with the other production methods. But does it have the potential to compete also in the future?

Cast coated products are usually associated with very high gloss. But in reality cast coating produces extremely high smoothness, gloss being developed for free. Having realised this fact, it is possible to produce a paper with extraordinary smoothness but matt appearance in addition to the glossy version.

The Cast Coating Process in General

The cast coating process consists of applying a coating color to one side of the paper and pressing it to the surface of a heated and highly polished chromium drum. Basically two different processes are in use nowadays: The low pressure process, invented by Champion (Figure 1), and the Warren process, using high pressure in the nip to the chromium drum (Figure 2).

In both of them the very high gloss (smoothness !) is developed by a thermoplastic deformation of the upper coating layer. No calandering needs to be applied. The lack of calandering keeps the caliper and all related parameters, e. g. stiffness and opacity, on a high level (Table 1). The porosity is high enough for printing with normal offset inks.

Table 1: Typical Values of Cast Coated and Gloss Coated Real Art Paper

	Cast Coated	Art Paper
Basis Weight, g/m2	135	135
Gloss, DIN 54502, 45	65	22
Caliper, µm	155	105
PPS, top side	0,35	0,55
Opacity at 90 g/m2	93,5	91,5

These wonderful specifications are associated with a fairly tricky process. At the Champion or low pressure process (Figure 1) the coating color is applied in access and without drying transfered to the big chromium cylinder. The final metering happens in the nip between the cylinder and a rubber roll. The pressure in the nip is relatively low and the diameter of the cylinder is large. The speed is far below 100m/min.

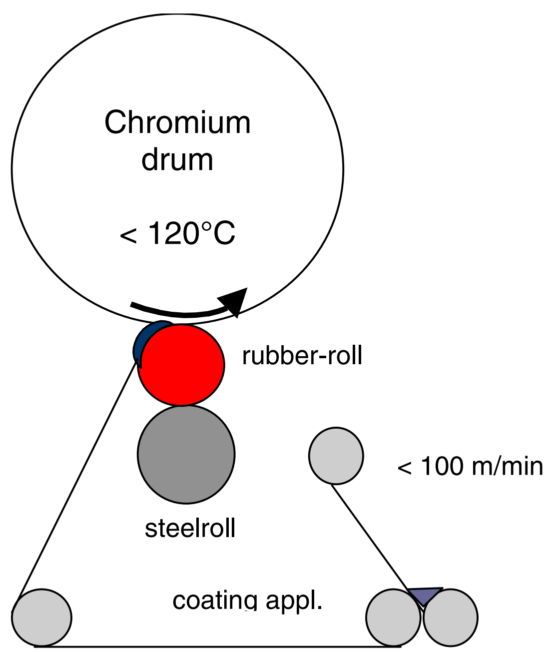

Figure 1. Champion or low Pressure Process

The S. D. Warren high pressure process instead allows production speeds of 200 m/min and higher. In this technology, the coating color is metered with an airknife after application and then dried. In the nip between the smaller chromium cylinder and a rubber roll, where a high pressure is applied, a water based release fluid is remoisturing the coated surface.

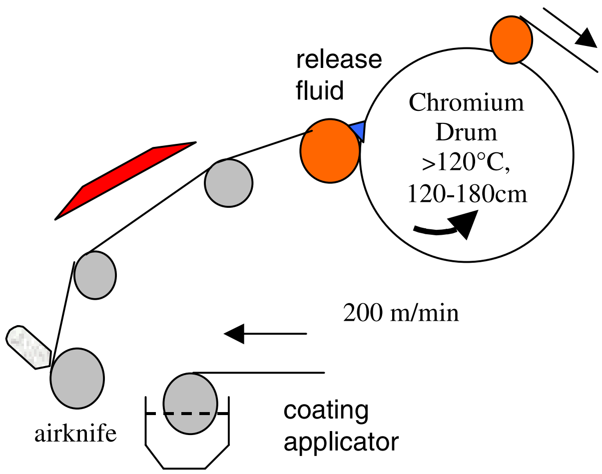

Figure 2. Warren or high pressure process

From the process description it is getting quite clear, what the key features are. First, the water of the release fluid is to be evaporated quickly from the surface of the cylinder through the coating layer, the base paper and the reverse side treatment. As a consequence, the coating needs to be very porous, the base paper well air permeable and absolutely free of any impurities. 2-side cast coated papers accordingly are very rare and expensive. On the other hand, the result is a porous all-paper product. Second, the wet coating layer needs to adhere closely to the cylinder in order to achieve a perfect surface, but has to leave the chromium surface without any molecule left. Any impurity on the drum rather immediately causes machine shut down.

Cast Coated Matt Surface

It was long time considered as being rather impossible to produce a matt cast coated paper. Several attempts have been made, which e. g. used prior gelation of the coating color or special pigments. Most of them resulted in a diminished gloss but still had glossy appearance. As mentioned before, gloss is for free with the cast coating process. Other trials involved coarse pigments and ended up similar, or the deformation of the coating layer did not take place, leading to an uneven and unattractive surface.

The final solution was the use of a profiled chromium cylinder having a distinct topography. The definition of the profile can be expressed by using the “Hommel-Tester”. The instrument is equipped with a diamant tip with a diameter of 5 µm. The tip is moving across the surface with minimum applied pressure. The deflection is measured by inductance . From the profiling curve the Mittenrauhwert Ra according to DIN 4768/1, the maximale Rauhtiefe Rt, according to DIN 4762/1E and the Wellentiefe Wt according to DIN 4774 are calculated. The Mittenrauhwert is the average, the maximale Rauhtiefe the maximum of the roughness profile without low frequency extensions. Wellentiefe is the waviness without high frequency roughness. Using a set of

Ra = 0,25 µm
Rt = 2,50 µm
Wt = 1,50 µm

in the paper results in a gloss range of 10 % – 15 % according to DIN 54502 (75° angle). For comparison, real matt finished coated freesheets would be at 5 to 8 % reflectance and silky grades from 8 % up to 18 %. The smoothness measured as Parker Print Surf (DIN-ISO 8791-4) is around 1,0 µm, corresponding to normal values of glossy coated papers. The combination of the low gloss but high smoothness is the reason for the very silky touch of this paper.

From the electron micrographs (Figure 3) the regular topography is well to be seen in comparison to the glossy cast coated product and a high gloss real art paper.

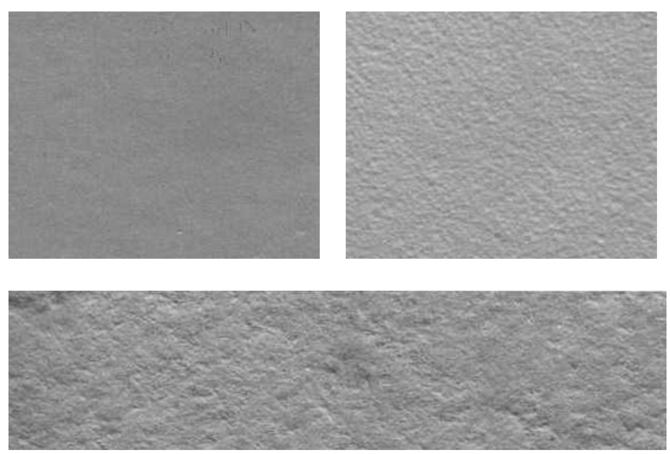

Figure 3. Paper surface electron micrographs. Bottom: high gloss real art paper; Left: glossy cast coated; Right: matt cast coated

Though principally the paper surface mirrors exactly the surface of the chromium cylinder, there are some deviations, probably due to the elasticity of the coating layer. The maximale Rauhtiefe and the Mittenrauhwert are slightly lower on the paper surface, the Wellentiefe slightly higher than on the cylinder.

PE-Laminated Inkjet Papers

First on the market were foto base papers, which were coated with an ink accepting layer. The producers of foto base paper had certainly realised, that there is coming up a new technology which might once jeopardise their business. Until today these products are containing a base paper with a plastic layer on each side. The plastic is in most cases PE and it can be extruded, dispersion coated or laminated. Extrusion is the dominating process (Figure 4). The glossy or matt surface is developed by attaching the hot melted PE, some 300° C, to a cooled Chromium Cylinder.

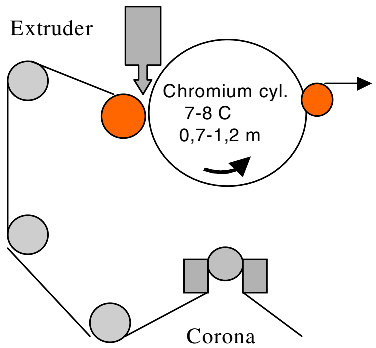

Figure 4. Extrusion Process

Both sides are laminated with approximately 20g/m2. The reverse side laminating is necessary for curl correction. A corona treatment or other primer application is essential for the adherence of the PE to the base paper. The process speed is limited to some 400 m/min, machine trims of 3-4 m are no problem.

It does not seem to be possible to construct an extruded polymer layer, which in itself is capable to absorb the water based inkjet ink. In so far this process will need an overcoat within the foreseeable future. Until now, these kinds of coatings consist of water based coating colors with a solid content up to 20%. They contain water soluble binders as PVAc, gelatine or others which make the formulations somehow difficult to handle concerning rheology and air bubbles. Coating application or metering is done by curtain coater, slot die or special multi-roll devices. As the ink is absorbed by the polymers through swelling (Figure 5), it is a diffusion controlled process, which needs time. The drying time is longer than for other papers, but gloss and surface appearance are superior.

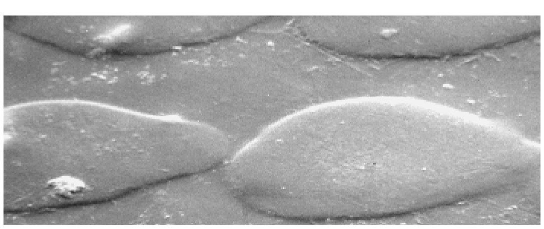

Figure 5. Ink Droplets after Swelling

It certainly is possible with this technology to apply a layer consisting of very small absorbing pigment particles, which appears glossy and still has got a shorter ink drying time than before. Limitation in that case is the coating thickness.

As there is no absorbing layer underneath the final coat, it has to absorb the full amount of the inkjet ink.

Discussion

Both, laminated fotopaper as well as cast coated paper may be taken as base for an inkjet absorbing top layer. This has been proven by commercially available products.

The real base paper, composed of fibers underneath the coating or laminating, has an important impact on the final quality. The formation, smoothness and evenness of this base paper is responsible for the final smoothness and overall appearance. A conventional foto base paper is supreme and yields the finest glossy inkjet surface. But it is also very expensive. At the end it is up to the customer to select the expensive and superb product or the slightly cheaper one. This makes no difference betweeen the two different technologies. Laminating as well as cast coating respond to the base paper generally in the same way.

When we try to compare the laminating and the cast coating process, assuming they both receive an overcoat later on, please take in mind that the authors are very familiar with cast coating, less with laminating. A 180 g/m2 sheet consists of 40 g PE and 140 g base paper for the laminated, 25 g pigment coating and 155 g base paper for the cast coated. The price of PE is significantly higher than base paper costs and slightly above coating material. Thus, material costs are in favor of cast coating. The speed of the different processes can be estimated to be actually 150 m/min for cast coating with a potential up to 250 m/min . 300 m/min can be assumed for laminating having a maximum potential of 400 m/min. While the cast coater can be managed by 2 people, the laminator needs 3-4. Energy is consumed at the cast coater for evaporation of the coating color water and heating of the chromium drum, at the laminator for melting the plastic at 300 C and the corona treatment. No significant difference is assumed here. At the end the operational costs may be comparable, including the higher speed of the extruder. Both processes need significant experience to have them run effectively.

The application of the inkjet layer does not show any significant differences for the two technologies.

The main difference in the final paper is the construction. The laminated product is a multi-component material while the cast coated is just a coated paper. On the top side, the PE layer prevents any cockle of the base paper, which can be a problem with the cast coated. Though for desktop applications it does not really matter, for large format a severe cockling appears to be prohibitive. Base papers have been developed with less response to water and reverse side treatments may be applied. On the reverse side, the PE layer prevents writing with a pen. The laminated products need an additional treatment for making this side writeable. Some discussions are around concerning the consumer preference. The plastic feel on the reverse side is considered to be more foto-like. Some people believe, the natural paper reverse side of the cast coated will become more accepted.

The limiting factor of the cast coating process, the quick evaporation through the total sheet, also bears a good option. For the evaporation, the surface needs to be porous and consequently it can be designed for absorbing the ink directly. This led to another version of glossy inkjet paper: the direct cast coated.

The inkjet suitable cast coating color can be applied on top of an uncoated or conventionally precoated paper and then guided to the chromium cylinder. It is the last step, the surface deformation on the cylinder, which produces the glossy or smooth/matt appearance. This opens the opportunity to use a variety of absorbing pigments, which by themselves would not produce gloss. As absorbency is the driving force, these surfaces are immediately dry and sufficiently water fast.

This third technology needs to be compared to the overcoated laminated or cast coated papers. One manufacturing step is left out, if the eventual precoat is applied at the paper machine or the cast coater. The speed on the cast coater is estimated to be a bit lower than for normal cast coating. The maximum speed may be some 150 m/min, 2 people operating.

Apart from the economical situation, the process itself differs to the competing technologies in a basic way. The surface, glossy or matt, is formed as the last step on a porous substrate. Whatever pigments are used in the coating color, the final deformation makes them glossy or silky. A lot of future potential is in this configuration. There is no plastic layer, which would prevent the use of the whole paper as a reservoir for the absorption of ink. On the other hand, the lack of this layer again increases the risk of cockling. Though the high absorption capacity of the inkjet layer and the precoat prevents most of the water to swell the fibers, there is a risk left, especially for large formate application. For some applications of the direct cast coated inkjet papers, base paper needs to be developed with less cockling tendency.

Finally it should be mentioned, that there will be a market for glossy coated inkjet papers , which will be coated on bigger machines more cost effective using conventional coating procedures designed for standard graphic work. But these will not be fotolike, because their smoothness cannot reach the cast coated or PE-laminated, as can be seen from Figure 3.

Conclusion

The cast coating process, used in the direct way to produce inkjet papers, is a comparable economical technology.

The unique feature is the manufacturing of a porous layer, which is deformed to the final surface appearance at the last production step. This allows for fast ink drying and good water fastness. For the future, a significant variability of the coating composition enables the producer to match other specifications. All other cast coating benefits, e. g. high caliper, are valid also for the inkjet application.

The production speed is limited. Cockling needs to be adressed basically as a base paper issue.

After all cast coated inkjet paper has got a good perspective for the future, as being cost effective and technologically unique.

Biographies

Gerd Papier finished studies of chemistry at the Free University of Berlin in 1977. He got his PHD at the Fritz-Haber-Institute, an institution of the Max-Planck Society. In 1990 he joined Zanders Feinpapiere AG as a member of R+D. Today he is director of Zanders Technology and Technical Service and of m-real Technology Center Speciality Papers. He is married and has two adult children.

Olaf Friederichs studied Paper Science and Engineering at the Technical University of Darmstadt and finished with the Masters Degree in 1996. He joined Zanders Feinpapiere AG the same year and started working on different projects in the field of Digital Printing Papers in the R&D department.

André Becker finished his education as chemical laboratory assistent in 1989 and worked with the Sihl company until 1992. Afterwards he studied at the FH Aachen and concluded as Chemical Engineer. He started his work for the Zanders Feinpapiere AG in 1997 as a member of R&D.