Ambient OPC conditioning effect outside and heat-induced interaction between the OPC and fuser belt inside the Océ VP6000 printer

Staszek Lenczowski; Dept. Engineering Consumables and Processes, R&D, Océ-Technologies B.V.; Venlo, The Netherlands

Abstract

The Océ Gemini Instant Duplex technology forms the heart of the Océ VarioPrint 6160/6200/6250 printer line. Since duplex productivity is key, the main technological issues that have been solved during development were architectural and robustness related. Robustness, in our philosophy, not only means large lifetimes of parts and consumables, but also a robust, constant and consistent performance and print quality of both print processes for various media and environments. To realize the necessary print quality robustness, we have made various innovations in the OPC, LED-printhead, transfer efficiency, transfuse robustness and process control.

In this contribution we will first describe the essentials of the printing process of the Océ VarioPrint 6160/6200/6250 printer line. After that, we elaborate a little further on the influence of ambient humidity conditions on the OPC-belt and its production process. Finally, the transfer-transfuse process and the heat interaction with the OPC-belt is discussed. These items represent two related print quality problems that had to be solved in order to realize a productive duplex print engine on an integral level.

Introduction

The Océ Gemini Instant Duplex technology of VarioPrint 6160/6200/6250 printer line (in short VP6000-series) consists of two mirrored printing-processes with only one transfuse step, so that front and back side images can be printed on the paper at the same time. This has not only enormous productivity advantages for double-sided printing, but is also very beneficial regarding front-to-back registration and energy consumption. This unique capability of transferring two images to both sides of the paper at the same time is facilitated by the proven Océ CopyPress technology. Furthermore, this CopyPress technology also forms the foundation for a good and very consistent print quality on all kinds of textured and non-uniform receiving media.

The printing process itself can be roughly divided into two main parts. The first part is the so called image-forming process, in which a toner image is developed on the organic photoconductor (OPC) belt. In the transfer pinch this toner image is transferred onto an intermediate rubber fuser belt (FB). Like the OPC is for the image-forming process, this FB forms the heart of the second part of the printing process, the transfer-transfuse (TTF) process. The main purpose of the TTF-process is to transport the toner image from the OPC-belt to the receiving medium, i.e. paper in most cases. In the transfuse pinch the toner image is pressed onto this receiving medium by means of pressure and temperature.

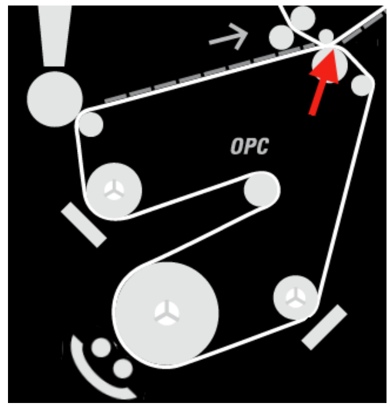

***Figure 1**. Schematics of the image-forming process of the VP6000-series. The smaller grey arrow indicates the rotation direction of the OPC-belt. At the larger red arrow the transfer pinch is located, which separates the image-forming from the transfer-transfuse process. Going clockwise from bottom left to bottom right, the charging function, the LED-printhead, the developing unit, the transfer pinch and the residual charge elimination function are indicated, respectively.*

Below we will first describe the essentials of the printing process of the VP6000-series. After that, we elaborate a little further on the influence of ambient humidity conditions on the OPC-belt and its production process. Finally, the transfer-transfuse process and the heat interaction with the OPC-belt is discussed. The main point of these items is that they represent two related print quality problems that had to be solved in order to realize a productive duplex print engine on an integral level.

Image-forming process

Let us start off with the basics of the image-forming process, which is depicted schematically in Figure 1. After the elimination of any residual charge from a previous printing cycle with an abundant amount of light, the endless OPC-belt is negatively charged to an apparent surface voltage (ASV) of –150 V by means of a double pin-array corona. Subsequently, the 600-dpi resolution LED-printhead locally discharges the photoconductor and writes the to-be-printed image on the OPC. In the developing nip the toner is then attracted to the OPC electrically at those positions where the OPC has remained charged (i.e., a so-called white writer). The VP6000-series uses a magnetic and conductive monocomponent toner, which is inductively charged in the developing nip. By means of a relatively small bias voltage compared to the ASV-value of the OPC, we are furthermore able to fine tune the normal toner development process and to avoid background development under varying process conditions. The final step of the image-forming process is the image transfer in the transfer nip, where the toner image is picked up adhesively by the soft rubber FB. The mechanics of this transfer pinch and the chemical composition of the silicone rubber toplayer are developed such as to realize a transfer efficiency of approximately 99%. In that way, the image-forming process can do without a traditionally used separate toner-cleaning function for the OPC-belt, since the small amount of residual toner can be recycled into the developing unit without any disturbing consequences during the next imaging cycle. The result is an intrinsic waste toner free situation.

In order to be productive on an integral level, not only process speed is important. Real productivity is a balanced combination of various items, among which a constant and consistent print quality. In the image-forming process of the VP6000-series, therefore, we have applied various control loops that ensures optimal parameter settings for the charging level, the printhead illumination value and the bias voltage in the developing process. Furthermore, the OPC uniformity specifications have been optimized accordingly, as will be discussed below.

Influence of ambient humidity conditions on the OPC

The OPC-belt essentially consists of 5 layers as sketched in Figure 2. The carrier is a polyester belt on which a metal layer (ML) of Ti is deposited. This ML is grounded via perforations in the carrier belt. On top of the ML there is the photosensitive generation layer (GL). The transport layer (TL) allows for the electrical transport of the generated holes in the GL under the influence of a sufficient electrical field supplied by the surface charge. The protective layer basically provides for an enhanced durability against mechanical wear.

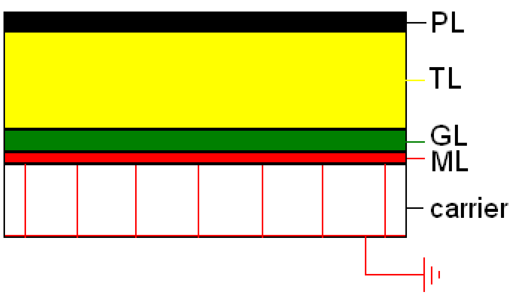

***Figure 2**. Schematic cross section of the OPC. PL represents a protective layer of about 0.2 μm, TL the transport layer of about 10 μm, GL the generation layer of about 0.5 μm and ML the metal layer of about 0.1 μm. The ML is grounded via perforations in the polyester carrier belt.*

As mentioned, the OPC-belt is charged to an ASV of –150 V by means of a double pin-array corona according

$$ASV = I_{charge} / (v_{OPC}\, w_{charge}\, C_{OPC}) - Q_c/C_{OPC}\,, \qquad (1)$$

with I_{charge} and w_{charge} the charging current and the width of the charging unit, respectively. The conditioning charge of the OPC is denoted as Q_c, whereas v_{OPC} and C_{OPC} are the velocity and the electrical capacitance of the OPC, respectively. By measuring the ASV-value during printing one can adjust the charging current in such a way that the average realized ASV on the OPC remains constant, independent of variations or degradation of the OPC parameters Q_c and C_{OPC} over time. Also differences between various OPC's can be accounted for. However, non-uniformities over the surface position of one OPC-belt, especially in Q_c, cannot easily be adjusted and can result in noticeable ASV-variations. These ASV-variations, in turn, may eventually lead to non-uniform grey reproduction on the print by compromising the integrity of small information.

So, in order to realize uniform charging of the OPC-belt it is important to control the uniformity of Q_c. It is known that the value of Q_c depends, a.o., on the exact composition and preparation conditions of especially the ML and the GL, as well as their interface topology. This means, therefore, that a good control over layer deposition processes is crucial to produce OPC's that are intrinsically uniform in Q_c. Also exterior conditions, however, can have a significant influence on Q_c. Figure 3 shows the relation between $1/L_{10V}$ and the square root of the ageing time for various ambient conditions. L_{10V} is a measure for the effective system discharge-sensitivity of the OPC and is inversely proportional to Q_c. We find that the saturation value of $1/L_{10V}$ (and Q_c) is dependent on the relative humidity (RH), and that the time constant involved in this ageing effect can be influenced by the temperature.

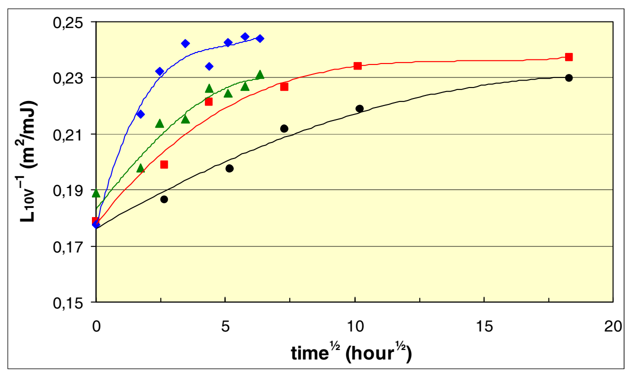

***Figure 3**. $1/L_{10V}$, which is proportional to Q_c, as a function of the square root of time, $\sqrt{t}$, for various ambient conditions (°C/RH). The blue diamonds represent 55°C/75%, the green triangles 35°C/75%, the red squares 35°C/50% and the black circles 17°C/50%. Graph reproduced by courtesy of Hans Hermans.*

We attribute the increase of Q_c as a function of the ambient RH to the absorption of water by the GL. The transport of water mainly through the TL is supposed to be governed by a diffusion process, which for short time (t) scales obeys

$$c/c_{eq} \sim \sqrt{t}\,, \qquad (2)$$

whereas for large time scales the moisture concentration, c, will saturate to an equilibrium value c_{eq}. At elevated temperatures one is able to accelerate the moisture absorption process of the OPC and realize a well reproducible saturation value for Q_c in an acceptable time period. Such a post conditioning process of the OPC also results in macroscopically more uniform Q_c-values well below 10% over the entire OPC surface position. This ensures in combination with the ASV and bias-voltage control loops enough latitude to realize background-free printing and stability of very small information like single 600-dpi pixel lines.

Transfer-transfuse (TTF) process and its interaction with the OPC-belt

The toner image that is developed onto the OPC in the developing nip is transferred to the TTF-process part in the transfer pinch. The central part of the TTF-process is the fuser belt (FB). This FB consists of a carrier tissue, a rubber intermediate EPDM-layer and a soft silicone rubber toplayer, schematically shown in Figure 4. During printing the FB is heated to approximately 105°C. This temperature is an optimal setting for the transfusing process of toner to the paper and the cleaning process of the FB itself. This cleaning process is developed to keep the FB free of paper dust, which could deteriorate the transfer process between OPC and FB. The actual cleaning of the FB is done with toner that is deposited onto a so-called spiral cleaner roller. The spiral cleaner roller further acts as a collector of the mixture of toner and paper dust.

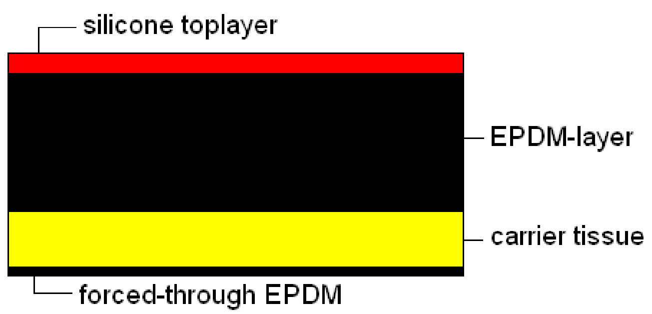

***Figure 4**. Schematic cross section of the FB. On the carrier tissue there is an EPDM-layer of approximately 1500 μm. The soft silicone rubber toplayer is about 100 μm thick.*

Since productivity is key for the VP6000-series, the temperature of the FB during standby is kept very near the operating value of 105°C that is used when printing. This ensures an immediate startup of the machine when a new print job is due. In the standby mode, the OPC, on the other hand, is generally not moving. This means that in the transfer pinch a small area of the OPC is facing a warm and therefore heat radiating FB over the entire width of the nip. So, at this position, the reverse effect of moisture absorption, as described in the previous section, may occur. This dehydration effect will lead to a decrease of Q_c. In principle a decrease of Q_c does not necessarily imply a deterioration of print quality. As already explained, the corresponding higher ASV level is adjusted to its default value again by lowering the charging current accordingly (Eq. 1). However, since this is a local Q_c decrease, the charging current adjustment cannot apply for the entire OPC surface. The result may either be a local band of background, or a decreased integrity of small information. Figure 5 shows an example of such a local band of background toner for an OPC that has been exposed to a warm FB during a standby period of 36 hours.

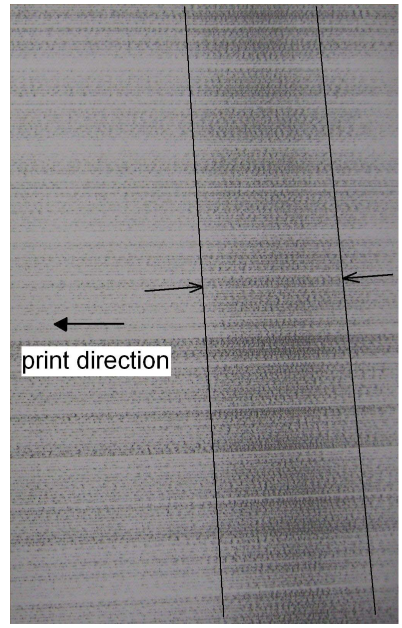

***Figure 5**. Band of background toner as a result of a heat interaction between the FB and the OPC during standby. For visibility reasons the development bias-voltage is adjusted such that background development is somewhat enhanced. The band of background toner stretches perpendicularly to the transport direction of the OPC-belt (print direction).*

Although the rate of dehydration is not as high as the absorption process of moisture, it is still a real practical problem. Figure 6 depicts the relative decrease of Q_c (or increase of L_{10V}) as a function of time. After 4 hours the relative change is about 20%, which is clearly visible on a normal print as background when the image-forming process parameters are not adjusted. The most obvious solution would be, of course, the elimination of the very source of the problem and lower the temperature of the FB during standby. However, for already mentioned productivity reasons, this is not an option. Another possibility would be to rotate the OPC also at a certain velocity. In that way, the OPC is irradiated not only homogeneously, but also to an almost negligible extent on average.

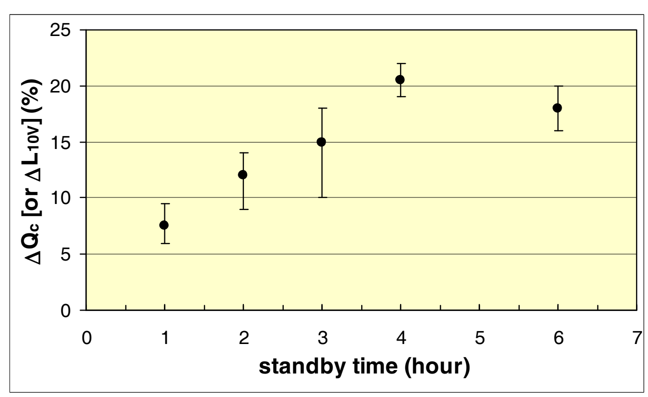

***Figure 6**. Relative change of Q_c (and L_{10V}) as a function of standby period. Graph reproduced by courtesy of Ralph van Mulken.*

Unfortunately, this is not a feasible route either, due to all kinds of toner dusting and pollution phenomena in the image-forming process. Instead, we have chosen to move the OPC discontinuously and very slowly in small steps. In this way, toner dusting appears to be no problem and the effects of heat irradiation on non-homogeneous dehydration of the OPC can be reduced to a completely negligible level.

Author Biography

Staszek Lenczowski received his MS in physics from the Eindhoven University of Technology (1989) and his PhD in applied physics also from the Eindhoven University of Technology (1995). Since then he has worked at the R&D division of Océ Technologies B.V. in Venlo, The Netherlands. His work has focused on the development and engineering of various toner-based printing processes and the engineering and industrialization of complex and multidisciplinary production processes of consumables.