

## Inkjet printing of Durethan® Polyamide and Pocan® PBT

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### 1. Introduction

There is an ever-increasing demand for permanent labeling on products. This may stem from customers requiring a barcode to provide complete component traceability in order to comply with product liability or from legislation requiring the plastic or the contents to be accurately labeled. The increasing individualization of products, especially in the leisure industry, also requires new technologies to label plastics. Furthermore, internal processes and logistics at the manufacturer's and protection from product piracy require additional labels. Components are frequently identified by adhesive labels, embossing or tampon, inkjet or laser printing.

Inkjet printing is becoming increasingly important in this application.

Printing is contact-free and is, therefore, well suited for use in production lines. Printing speeds of up to 10 m/s are also an advantage. It is flexible to use, as the print format can be changed at any time at short notice without incurring any costs for a new printing plate or mask. Multi-colored prints in photo quality are also possible. This enables products to be customized quickly and easily.



Figure 1 Printed component and laminate

As the process is based on "simple" printer technology, the running costs are low and the investment costs in comparison to alternative printing processes are extremely low. As a rule, the plastic surfaces do not have to be pre-treated, and there is no need for an additive in the plastic to ensure its printability. However, not all inks are equally well suited to all applications. For this reason, the complete system, consisting of matrix material, printer, parameters and ink, has to be adapted to suit.

## 2. Processes

In inkjet printing, three different technologies have become established. They are briefly described here:

### 2.1 Valve technique

Technically this method is the most straightforward. The ink is transported from the ink tank to the print head. This consists of several nozzles with a typical diameter of 200  $\mu\text{m}$ . Each nozzle is fitted with a valve. If an ink droplet is required the valve is opened and the ink is sprayed from the nozzle due to the pressure applied.

This technology has the disadvantage of the ink remaining in the nozzle until it is required. This can lead to fluctuations in the quality of the printed image or to the individual nozzles becoming blocked. The print head has to be cleaned regularly.

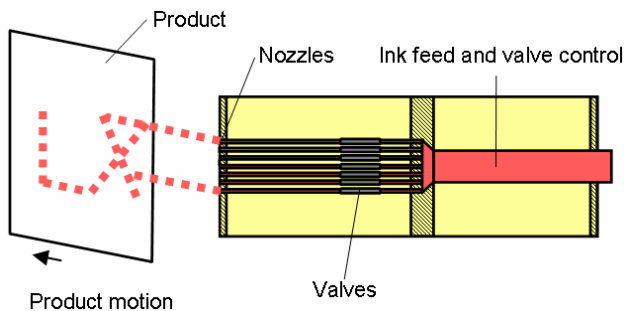


Figure 2 Schematic diagram of the valve technique

### 2.2 Continuous inkjet

In continuous inkjet printing, the ink is transported under pressure from the tank to the nozzle, where the ink forms a continuous jet which is broken down by a piezo unit into droplets of equal size as soon as it leaves the nozzle. These droplets are then placed under different electric charges using charging electronics. The charged droplets then pass through a constant electric field where they are deflected in various ways depending on their charge. The droplets then end up on the surface to be printed. The printed image therefore corresponds to the charge pattern of the droplets. Droplets that have not been charged are collected and returned to the ink tank.

As the ink jet is constantly in motion, the nozzle cannot dry up and the printed image is of consistent quality.

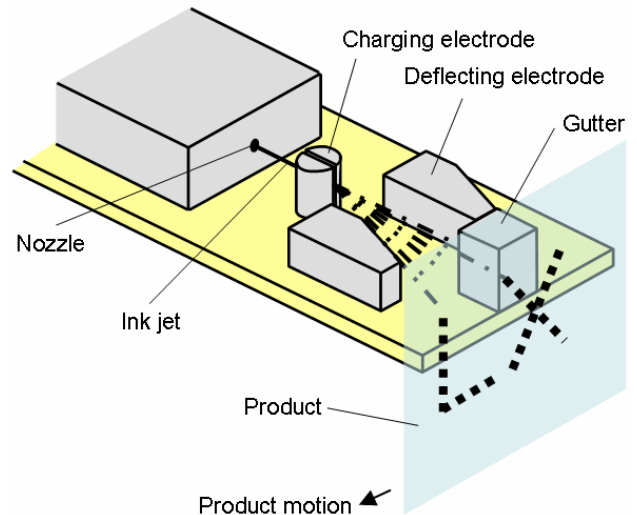


Figure 3 Continuous inkjet printing

### 2.3 Impulse technique

Impulse print heads were originally developed for the office printer market but are becoming increasingly important for the labeling of components. There are two types of impulse printing: the piezo technique and the bubble jet technique.

#### 2.3.1 Piezo technique

The ink is fed under low pressure to the nozzle and held there by surface tension. Behind the nozzle is a nozzle chamber fitted with a piezo element. If an electrical impulse is applied to this piezo crystal, the crystal changes shape and this reduces the volume of the chamber. This causes an ink droplet to be propelled from the nozzle. Once the electrical impulse ends, the crystal returns to its original shape. Due to the capillary forces resulting from the surface tension of the ink (among other things), ink is drawn from the ink supply and the nozzle is refilled.

In this technique, the ink also remains in the nozzle. If one or more nozzles are not required for some time the ink can dry up. This causes fluctuations in the print quality. In the piezo technique, the print heads can also be sensitive to vibrations. If the nozzle is shaken too hard, the surface tension may not be sufficient to keep the ink in the nozzle and to

supply the nozzle chamber with enough ink from the tank. It then has to be pumped manually.

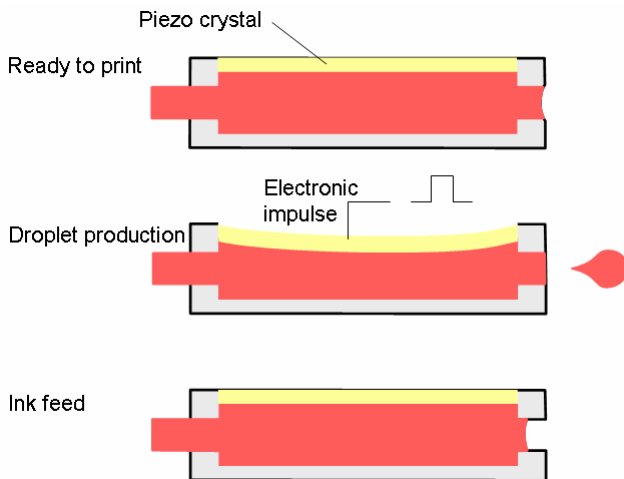


Figure 4 Schematic diagram of the Piezo technique

### 2.3.2 Bubble jet technique

The latest development in impulse technology is mainly used in offices. The structure of the print head is similar to the print head used in the piezo technique, except that the piezo crystal is replaced by two electrodes. The electrical impulse at both poles produces so much heat that the ink partially evaporates. A vapor bubble is produced which propels an ink droplet from the nozzle. If the voltage is switched off, the vapor bubble collapses and the nozzle is refilled with ink due to the capillary forces.

In this technique too, the ink can dry up in the nozzle and can be shaken from the nozzle when subject to excessive vibrations.

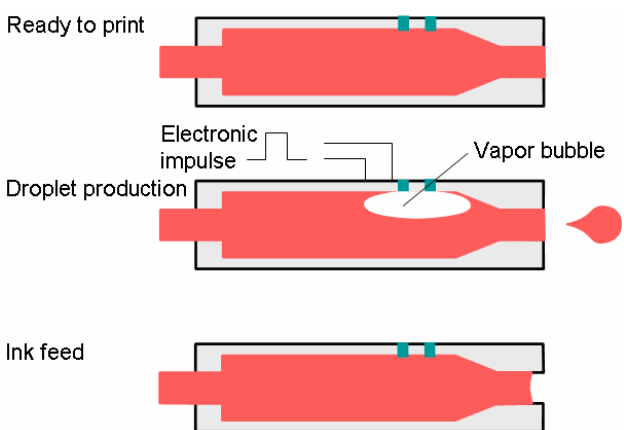


Figure 5 Schematic diagram of the bubble jet technique

### 3. Printing Durethan and Pocan

Polyamide and polybutylene terephthalate have been used in printing for a long time. However, the print quality greatly depends on the interaction between the process, the ink and the matrix polymer. For example, certain inks can only be applied to the matrix with certain printing processes. In addition, the ink also has to be adapted to the matrix to achieve good adhesion. In some cases, the ink may have to be subsequently cured by means of UV or infrared radiation or even just heated in an oven. This gives the cured inks their special qualities.

The ink is, therefore, selected on the basis of the matrix material and the print quality requirements. Important quality requirements may be abrasion resistance, resistance to chemicals and heat, color, food contact applications etc.

The following tests were performed with Tritron GmbH (Bahnhofstrasse 26, D-35088 Battenberg/Eder). The "N-Gen" ink system was used. This is a heat-curing, water-based ink specially developed for use on PA and PBT and also suitable for high-resolution printing. This ink was printed on test sheets after application of a chemical color gradient control using the micro-piezo technique on a commercially available office printer. The color gradient control prevented the individual ink droplets from flowing into one another and mixing together. The substrates selected were Durethan B 30 S (PA 6), Durethan BKV 30 (PA 6 GF 30) and Pocan B 1305 (PBT). After applying the ink, they were cured in an oven. This brought about esterification in the ink, which should make it resistant to mechanical and chemical stresses. These two criteria were then tested.

### 4.1 Mechanical properties

An important mechanical property is the adhesion of the ink to the matrix. It is very easy to test this adhesion by a cross hatch tape test. In accordance with DIN EN ISO 2409, a cross hatch is cut into the colored layer with a sharp blade and a strong adhesive tape is stuck to the layer and pulled off. Adhesion

can then be determined using the number of squares stripped off.



Figure 6 Cross hatch test

The adhesive tape test did not cause any impairment of the printed image in the tested system consisting of ink and Durethan or Pocan. Even conditioning the samples in hot water did not change the

adhesive tape test results. Examination of a cut face under the microscope did not reveal any penetration of the ink into the material.

#### 4.2 Chemical properties

In addition to mechanical properties, resistance to chemicals and solvents is a frequent requirement. To test this, samples were placed in various media for 24 hours at room temperature. Then the printed side of the sample was manually rubbed with a cellulose cloth.

Overall, the tested system consisting of ink and Durethan or Pocan displayed very good resistance to many solvents. No impairment of the printed image was observed after storage in petrol, acetic acid, cyclohexane and diethyl ether. A good result was also achieved with ethanol. Resistance to oils was tested using silicone oil. Here too there was no impairment of the printed image. Only after storage in dichloromethane and sodium hydroxide was there discoloration of the printed image and the cellulose cloth in the case of polyamide.

The results of this series of tests are summarized in the following table. This shows the assessment of discoloration in the cellulose cloth, test sheet and liquid.

Discoloration of		Silicone oil	Cyclohexane	Sodium hydroxide 0.1 mol/l	Acetic acid 0.1 mol/l	Ethanol	Dichloromethane	Diethyl ether*	Petrol
<b>Durethan B 30 S</b>	Test liquid	+	+	+	+	+	+	+	+
	Cellulose cloth	+	+	-	+	-	-	+	+
	Test plaque	+	+	-	+	+	-	+	+
<b>Durethan BKV 30</b>	Test liquid	+	+	+	+	+	+	+	+
	Cellulose cloth	+	+	-	+	+	+	+	+
	Test plaque	+	+	-	+	+	+	+	+
<b>Pocan B 1305</b>	Test liquid	+	+	+	+	+	+	+	+
	Cellulose cloth	+	+	+	+	+	+	+	+
	Test plaque	+	+	+	+	+	+	+	+

Table 1 Resistance of N-Gen printed images on Durethan and Pocan after 24 hours' storage in chemicals at room temperature (\* = stored for 5 hours)



### 4.3 Weathering

A weathering test in accordance with DIN EN ISO 4892-2 for 1000 hours simulated the stress from (solar) radiation, heat, rain and damp.



Figure 7 Sheets which have not been weathered (top) and weathered test sheets (bottom)

The results showed that the print was very stable to weathering overall. Weathering did not change the

surface structure of the printed areas, whereas the unprinted areas became rougher and slowly discolored under the influence of UV radiation and light as well as damp. The black ink, in particular, displayed good resistance to UV radiation; the black printed areas did not change in this test. The other colors also displayed good resistance to UV radiation but there was a shift in their color spectrum to blue and red. At the same time, the colors faded; they became lighter, which made the contrast between the weathered sample and the reference sample greater.

### 5. Summary

The need to label and individualize plastics is constantly increasing. A process well suited to this is inkjet printing. It is fast, cost-effective and easy to use.

The combination of the “N-Gen” ink system from the Tritron Company with Durethan and Pocan exhibits good mechanical properties, very good resistance to solvents and high UV stability.

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