Gravure printing

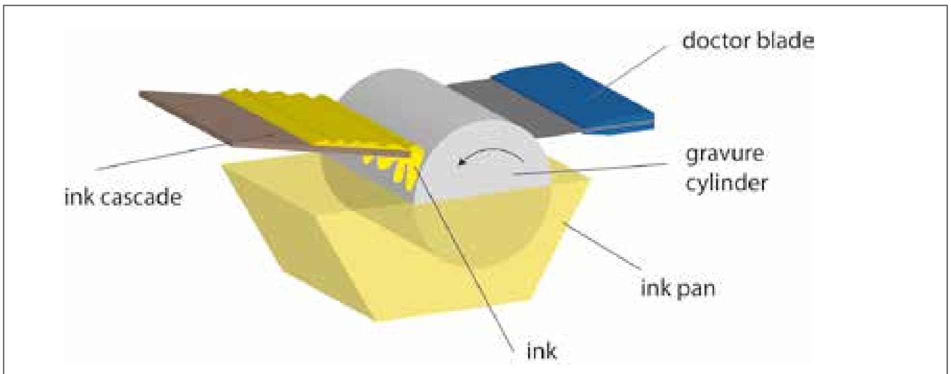
Doctor-blade based gravure printing

Gravure printing using a doctor-blade is the leading industrial gravure printing method. A distinction is made between illustration gravure printing, packaging printing, including label gravure printing, and decorative gravure printing. All these methods are based on a common basic ink transfer principle. The (engraved) printing forme cylinder carries the image to be printed in the form of cells. The area of the printing elements as well as their depth, hence the amount of ink that can be transferred, vary depending on the cell characteristics. This principle enables doctor-blade based gravure printing to produce nearly realistic continuous tones in the printed image. The method is particularly strong in the printing of images. Compared with the other conventional printing methods, doctor-blade based gravure printing has the widest colour space. On the other hand, full uniform screening of all printing elements causes some lack of detail sharpness (saw-tooth effect) at the edges of type characters and finer lines.

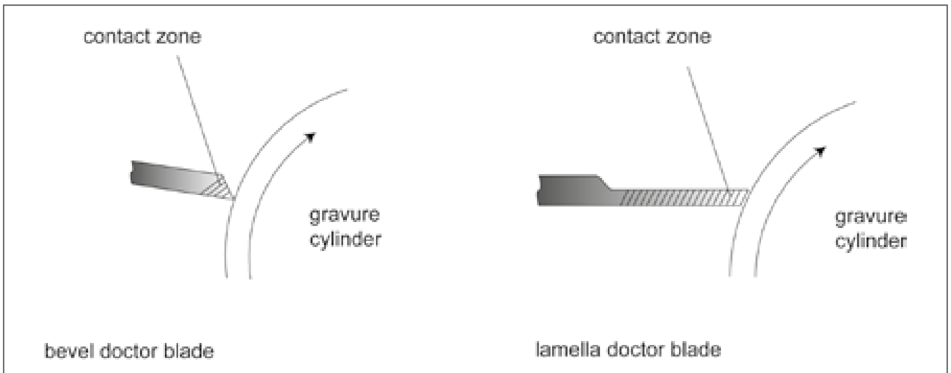
The inking and printing process is comparatively easy. The engraved printing (gravure) cylinder rotates and is partially submerged in the ink pan. As a result, the engraved cells are flooded with ink. Then a doctor-blade wipes off the excess ink from the surface. In the contact zone between the gravure cylinder and the impression roller, the substrate takes off the ink from the cells. The inking process of the engraved printing cylinder is normally supported by additional devices. For instance, inking cascades and inking rollers are used to ensure filling of the cells. The ink cascade also makes sure that drying of the emptied cells is reduced to a minimum since the printing cylinder is already flooded with ink again immediately after the printing nip. In particular, the highlight areas (finest cell structures) tend do dry very fast and cause losses in the printed image. This loss is also called "missing dots".

The inking roller is a supportive system in the ink pan. It rotates with slight pressure against the printing cylinder, reducing any existing air entrapping in the cells to a minimum and making sure that the cells are filled with ink. The inking roller is an elastic rubber roller optionally provided with a cover (illustration gravure printing) and/or a specially structured surface (packaging printing and decorative printing).

As soon as the cells have been filled, excess ink is removed with the doctor-blade. At this point, the ink metering system determines the amount of ink applied depending on the cell volume. The doctor-blade oscillates from side to side in order to prevent the gravure cylinder surface from being damaged by the scraping process. The doctor-blade is a positive doctor-blade, i.e. running parallel. In order to counteract high wear at the scraping point, a minimal ink film (as lubricant) is required under the doctor-blade. There are a large number of different forces acting on the doctor-blade. The most important one is the contact pressure acting vertical to the cylinder direction, which is transferred to the doctor-blades by the blade beam. This force is spread to the gravure cylinder via the positively angled blade so that the blade lies flush on the cylinder. The second force acts in rotational direction on the back side of the blade and results from the hydraulic pressure of the printing ink, which, in turn, is dependent on the viscosity of the ink. If the viscosity of the ink is too high, the increasing hydraulic pressure makes the blade take off from the cylinder; in this case, the ink can pass the doctor-blade contact point in an uncontrolled manner. This phenomenon is sometimes also called "blade fluttering". A third force acts on the cutting edge of the blade from below in the form of the thin ink film. The generation of the lubricating ink film is influenced by the surface roughness of the cylinder. Many gravure cylinder manufacturers process the copper-coated, unengraved cylinder in a separate grinding process and produce defined surface structures. The doctor-blades used are extremely thin steel knives. They optimally adapt to the cylinder surface and



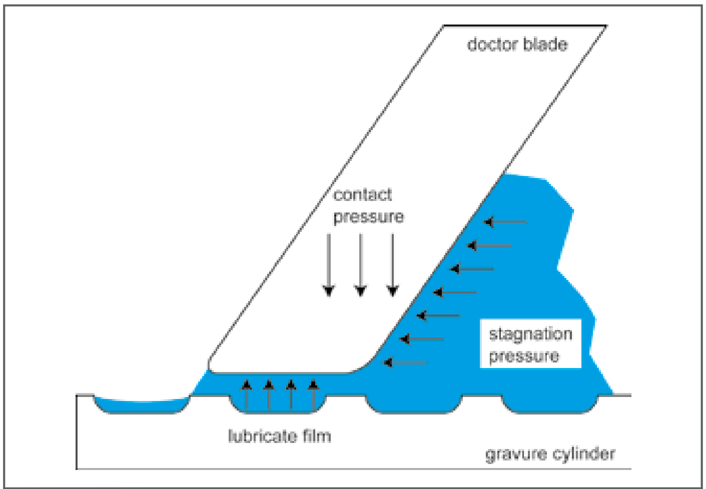
Cascade inking and inking roller



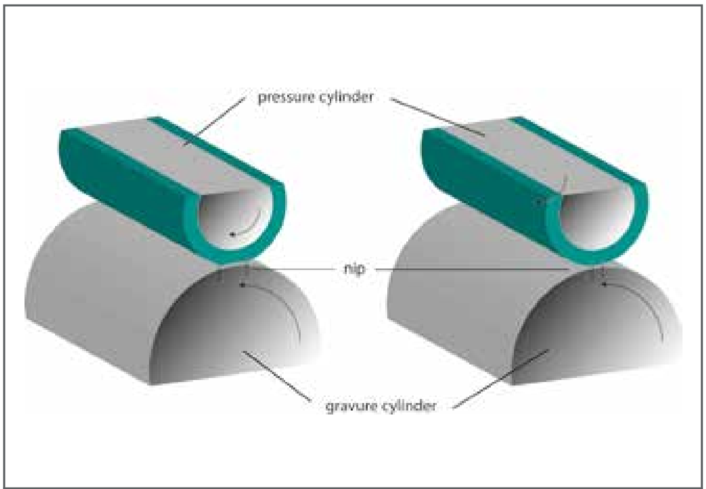
Wedge-shaped, bevelled doctor-blade and lamella doctor-blade feature the necessary dimensional stability. Normally, two variants are offered. The conventional doctor-blade with a V-shaped cutting edge is based on a rectangular block with a partially ground bevel. This doctor-blade is suited for normal demands for the production of mixed halftone and solid printing products. While the print run stability is good, the tonal values in halftone printing vary depending on the state of the bevelled edge of the doctor-blade. With increasing wear at the blade tip, the contact area on the gravure cylinder increases. As a result, the halftone values in the printed image slightly increase. For high-quality halftone printing, doctor-blades with a lamella profile (stepped edge) have been developed. They feature a thin partially ground lamella at the tip of the knife. The size of the lamella corresponds with the wear area of the doctor-blade and perfectly adapts to the cylinder surface after a few rotations already due to its thin cutting edge. In the course of the printing process, wear only reduces the length of the lamella. The contact area on the gravure cylinder, however, remains nearly constant.

Another important parameter in doctor-blade based gravure printing is the contact area between the printing cylinder and impression roller with the substrate in between. This contact area is also called nip. The nip is substantially determined by the hardness of the impression roller. A soft impression roller produces a wider contact zone. The substrate has more time to take the ink from the cells. On the other hand, edge sharpness of the printed image will decrease. The figure shows the effects of the impression roller hardness on the width of the nip. The roller covering is made of rubber (elastomer). The hardness of the impression roller is measured in ° Shore (A). The higher ° Shore (A), the harder the covering and the smaller the nip.

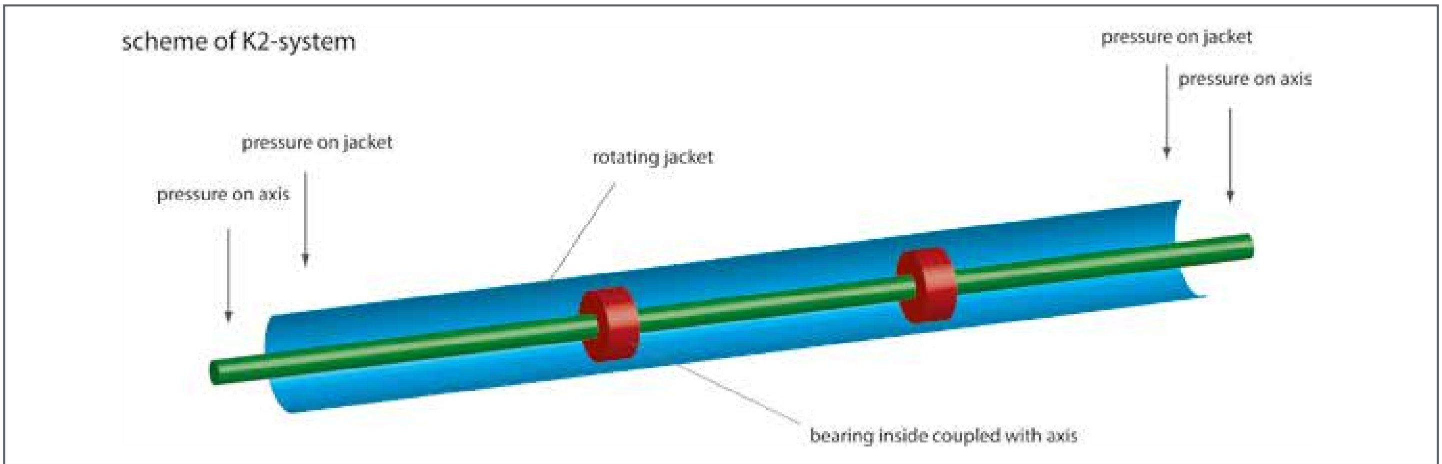
While the nip is the contact zone created in cylinder circumferential direction, the impression line describes the contact between the gravure cylinder and the impression roller along the length of the cylinder, i.e. the nip width. The influence of the impression line is especially obvious in wide illustration gravure printing machines. With working widths of more than 2m, the deflection of the gravure cylinder due to its own weight has a negative effect on the impression line. In the worst case, the result will be a total loss of contact between the substrate and the printing cylinder and, in the end, deficiencies in the printing process if no countermeasures are taken. The necessity of print deflection compensation depends on the working width of the printing machine. Roughly, there are three categories. Printing machines with a working width of approx. 1m do not need any additional equipment. Machines having a working width between 1m and 2m are often equipped with an additional steel impression roller above the normal rubber-coated impression roller. Due to its dead weight, the steel impression cylinder bends the elastomer impression cylinder in the direction of the printing cylinder. The resulting forced position of the elastomer roller reminds of a sandwich and ensures sufficient contact between the printing cylinder and the substrate. Where the working width is larger than 2m, this system can no longer be used. Deflection will be so strong that the impression roller can no longer follow. In order to solve this problem, the flexible impression roller was developed. Additional equipment enables it to be deflected until reliable contact is ensured. For the flexible impression roller, different technologies are available. The K2 impression roller has supporting bearers inside. By means of two separate hydraulic systems, pressure can be applied to the jacket or the axis separately in order to produce the necessary deflection. The S impression roller consists of a fixed impression roller core



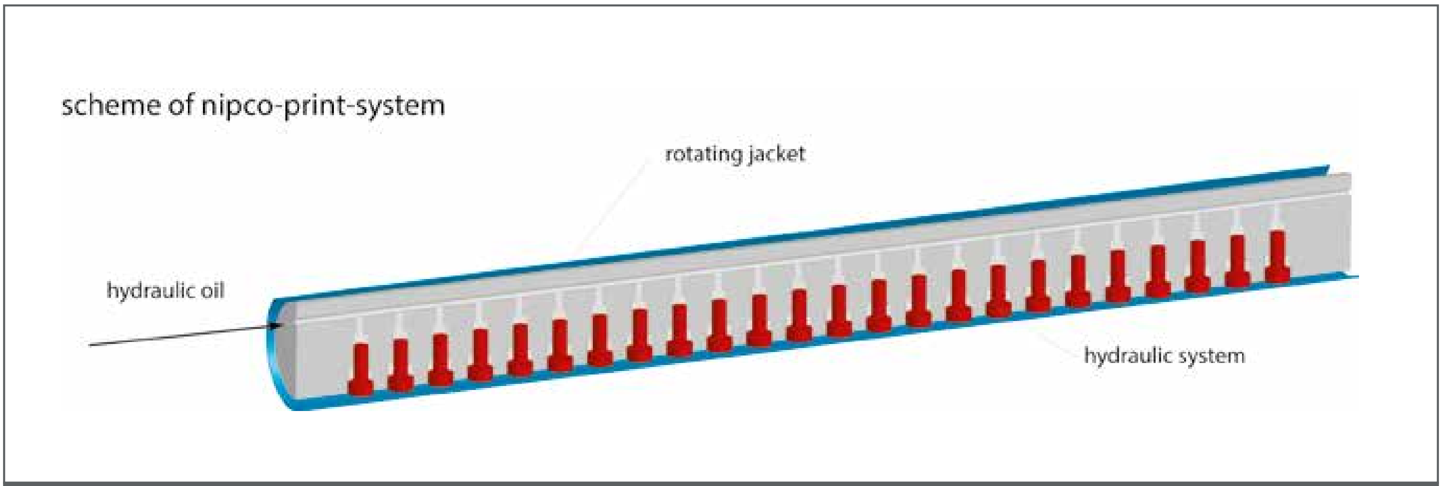
The forces acting on the doctor-blade



Interrelationship between impression roller hardness and the nip



The K2 impression roller Nipco Print impression roller



The Nipco Print impression roller

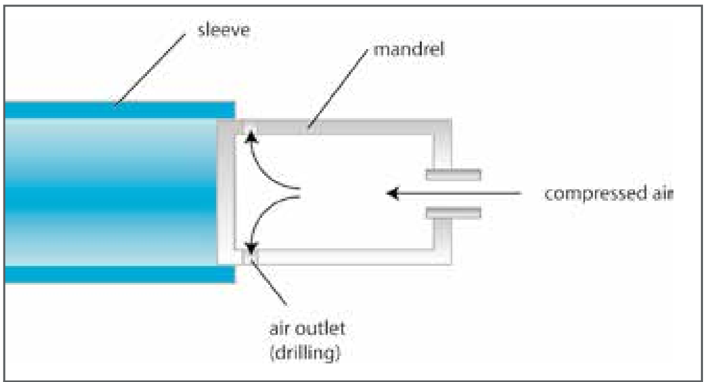
covered by a rotating jacket. In the impression roller core, there are channels through which hydraulic oil is pumped in order to stretch the impression roller jacket towards the gravure cylinder. A similar method is used in the Nipco print impression roller system. It has an impression roller core with a hydraulic system covered by a rotating, elastic jacket. By means of the hydraulic stamps, the impression roller jacket can be pressed towards the gravure cylinder in high precision.

In packaging gravure printing, most working widths are in the range between 1.2 and 1.6m. The deflection of the impression roller is compensated for with an additional steel impression roller. Aspects that are more important for packaging printers due to frequent substrate changes and shorter and shorter print runs are fast make-ready of the printing press and the adjustment of the impression roller properties. For these requirements on the machines, modern sleeve technology has proved very useful. With the sleeve technology, heavy cylinders with fixed shafts are replaced with lightweight sleeves. This makes handling much easier for the printer and reduces the make-ready times.

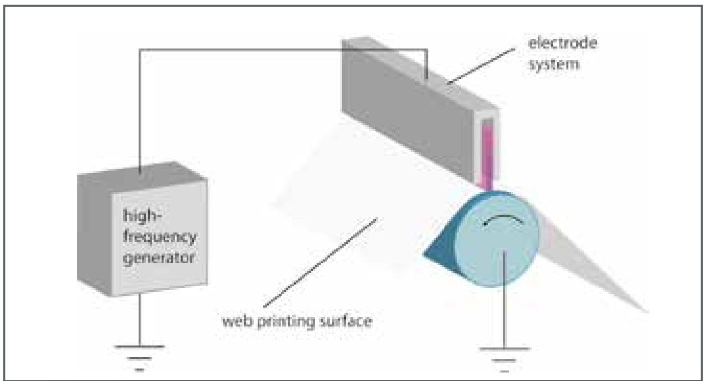
Finally, we will now have a look at the printing inks used in doctor-blade based gravure printing. The printing inks used in this process are low-viscous inks. Depending on the requirements, the ink manufacturers offer water-based and organic solvent based inks. Normally, gravure printers do not use ready-to print ink containers, but produce their own printing ink according to specific recipes in their own ink kitchen. The ink mixing systems used by them mostly comprise 11 to 15 base inks. In addition, binding agents and solvents are used to set the colour brightness and/or pigment concentration as well as the viscosity. The recipes and the colour mixtures are produced computer-controlled and cover both base inks and special (spot) colour inks.

Printing on non-absorbent substrates (e.g., plastic films and composite materials) requires pretreatment of the surface in doctor-blade based gravure printing as well. The mostly non-polar plastic surfaces prevent the printing ink from anchoring solidly. The leading method for an adjustment of the surface tension is the corona pretreatment. This method uses a high-frequency generator to produce high alternating voltage. Via an electrode system, the charge carriers are transferred to the substrate and thus produce an activation of the surface so that the printing ink or the adhesive can be applied. The decisive factor for a successful surface activation is the amount of transferred energy per area unit. Therefore, it is necessary to align the pretreatment with the machine speed. Overtreatment with load carriers can damage or even destroy the film web.

Text and images: Ronald Weidel (azp Chemnitz)



Sleeve and mandrel



The basic principle of corona pretreatment