

Manuscript / Extended Abstract

Coating Application in Comparison – Gravure roller technique (contact) vs. Curtain technique (non-contact)

Introduction

Application systems with gravure rolls are now standard on most coating and laminating machines. The latest curtain coating technology, however, represents an interesting option for many applications.

This presentation will provide an overview of both techniques from a machine builder's point of view. It will describe the differences between the two techniques, outline the respective limits and detail the advantages and disadvantages of both systems. Where are the limits? What parameters have to be considered with regard to both techniques? The technical and commercial backgrounds will be compared and useful advice given about the selection of the most suitable technique.

The Kroenert Group

The headquarter of the Kroenert Group is located in Hamburg, Germany. Kroenert has been founded back in 1903 as a manufacturer of wall paper printing machines.

Over the centuries Kroenert became a worldwide acting specialist for the delivery of coating and laminating machines for all kind of web-like materials.

Today known as the Kroenert Group, the following companies are members:

- Kroenert, Competence Centre for the coating technology, including Technology Center
- Kroenert Corporation for sales and service of the North-American market
- Drytec as the specialist for drying and remousturizing equipment
- Bachofen and Meier as the Competence Center for modular standard machines

The Kroenert Group is still privately owned, with approx. 400 employees and a turnover of about € 120 Mio (2008)

Overview of typical products produced on machine delivered by the Kroenert group:

- Packaging
- PSA-applications
- Silicone release applications
- Composites
- Imaging materials
- Battery structures
- Specialty structures
- Radiation curables
- Tapes
- Furnishing
- Electronic
- Medical/pharmacy
- Components for solar panels
- Barrier coatings with i.e. Nanostructures

Which machine elements are typical for the production of most of the mentioned products?

A perfect example is the production **scaled R&D line in the Technology Center of the Kroenert Group**.

For the topic of today a roller coating station with removable roller trolley (right) , for example for gravure coatings is available as well an independent coating station for curtain coating application with 1-layer slot die plus 3-layer slide die (left).

Coating Techniques - Overview

Different coating systems are available for several applications and established in the market (see table of coating systems).

The overview shows the difference between self-metering and pre-metering coating systems. Both systems differ in contact and non-contact applications.

Self-metering systems operating in contact mode using multiple rollers with adjustable nip pressure and differential speeds to meter the application compound.

The pre-metering systems can operate either in contact as well as also in non-contact mode. All pre-metering systems are operating with elements to dose the coating compound, before it will be transferred onto the web.

This presentation is focusing on two pre-metering systems: gravure coating (contact) vs. curtain coating (non-contact).

Gravure Technique, principle (contact)

Gravure roll coatings are in operation for water- and solvent based application of all kind of primers, lacquers, adhesives and other functional layers like i.e. barriers and also for solvent less compounds.

The gravure system operates in direct contact to the web.

Easy to handle is the well-known conventional gravure with screen roller, pan and oscillating doctor blade. The coating weight will be determined by the cell volume of the screen roller.

To reduce the volatilization of solvents the conventional gravure system can be substituted by a chamber system. Open pan will be replaced, the volume of coating compound will be reduced.

The pressurized chamber system, for example the Kroenert MPG 600 is combining the above mentioned advantages. Additionally different coat weights can be easily adjusted by using a PC-based pressure control device in combination with a hatched screen roller.

As a complete closed system also the volatilization of solvents is prevented as well as any foaming problems.

Curtain technique, principle (non contact)

In non-contact curtain coating a highly precise die is installed at an adjustable distance of several centimeters above a web of material running horizontally. The coating compound falls freely from the slot, creating a curtain and leading to an unstructured, enclosed and very even contour coat on the substrate.

Coat weight is a function of flow rate and web speed. Operation with water- and solvent based coating compounds is possible.

Typical applications with 1-Layer Slot-Die:

Water-based adhesive application, Inkjet, CB/CF coatings, Pigmented coats for the painting industry, solvent-based coating compounds

Typical applications with 3-Layer (or multiple) Slide-Die:

Packaging (solvent-based lacquers) for heat sealing lacquer and PVC primer/PVC heat sealing lacquer, Photography, Digital imaging, Inkjet papers, Laminate for floor coverings, Adhesive tapes and labels, Pharmaceuticals, Medical diagnostics, Decorative papers, Fuel cells etc.

What are the important parameters to choose the right coating technique?

The following diagrams are showing the dependence of the coat weight and viscosity in accordance to the required production speed for each coating system.

Coating Techniques –Limits by coat weight

The different coating techniques are limited by the coat weight. For example the multiple rollers to a maximum coat weight and the metering nip with comma bar to a minimum coat weight.

This presentation will focus in particular on the following Systems:

- Gravure (contact)
- Curtain coating (non-contact)

As shown on the diagram the gravure system covers a wide range in coat weight and various speeds up to approx. 1200 m/min production speed.

Due to the required minimum flow rate to establish a curtain the curtain coating system is limited in lower coat weights at lower speeds, but it is capable for higher speeds.

Coating Techniques – Limits by viscosity

The evaluation of the coating techniques need to consider also the viscosity depending on production speed.

Multiple rollers systems are limited by lower viscosity. The systems for higher viscosities are metering nip with comma and die applications.

The focus on gravure (contact) and curtain coating (non-contact) shows again two conclusions:

- Gravure is capable for higher viscosities (up to about 1200 mPas)
- Curtain coating is limited in lower viscosity (up to about 300 mPas)

Comparison gravure vs. curtain

The following tables presenting an overview about differences and limits to compare the contact type gravure coating system (based on the sophisticated pressurized chamber system) with the non-contact curtain coating system.

The comparison should help to choose the suitable coating technique and will focus on the major items, for details please see your files.

Upper speed limit for gravure coatings is based on the coating system due to the required emptying of the cells of the screen roller.

The upper limit for curtain coating is mainly based on the layout of the production machine (i.e. dryer capacity) and logistics (reel transport and preparation).

Lower speed limit for gravure coating is not an issue. For curtain coating a minimum flow rate to establish a curtain is required.

Both coating system, gravure with pressurized chamber as well as curtain coating, do not need to be operated in combination with an inline coat weight measuring unit. But both systems can be linked to such a systems for a closed-loop-control of the coat weight (measuring system detects the implicated coat weight and controls the pump pressure of the supply system in accordance to a set point).

This slide presents an overview in figures on **coat weight and viscosity** (see diagrams above).

For both coating techniques, gravure and curtain, the stability of the viscosity is important for the application process.

Gravure coating stresses the compound by the contact between roller and the web plus the blade pressure.

Curtain coating is stressful to the compound because of the pressure increase due to the narrow slot of the die.

Also the **surface tension of the coating compound** has to be checked.

For gravure coating the surface tension of standard water- and solvent based as well as solvent less compounds is acceptable, adaptation of materials to be coated is possible, for example by primer coating or corona treatment.

For curtain coating a variation of viscosity (lower or higher) destroys coat weight uniformity and the curtain breaks down. This results in requirement of wetting agents to reduce surface tension to establish the curtain.

Depending on the quality of the Slot -Die manufacturing process the achievable tolerance in coat weight is better with curtain coating.

Important is the manufacturing process (grade of fine tuning of the inner die surfaces). Also range in specification influences the quality (less differences in coating compounds allows better adapted design of the die).

For gravure coatings the manufacturing process of the screen roller plus the design of the pressurized chamber results in the mentioned tolerance.

Gravure coating operates normally as a re-circulating system (just a few exceptions are known).

Curtain coating requires no circulation, because the medium will be transferred in 100% onto the web. Just a minor amount of compound needs to be re-circulated for the edge guide units (for 1-layer dies; for multiple layer dies it might be wasted).

The Curtain Coating equipment requires a well filtered coating media to prevent blocking of the system. Particle size depends on the precise slot die opening.

Gravure coating systems are much more flexible regarding the compound.

Air free coating compound is a need for curtain coating otherwise the curtain might break or air bubbles resulting in coating defects.

Because of the contact application this is not a major issue for gravure coating.

With the **sophisticated pressurized chamber system gravure coating** allows the variance in coat weight with one screen roller up to $\pm 40\%$ by controlling the pressure inside the chamber. The pump pressure needs to be adjusted.

Remark: the conventional gravure system with pan or simple chamber requires a screen roller change in accordance to the required coat weight or production speed.

For curtain coating the coat weight can be adjusted by the flow rate of the compound through the die also by adjusting the pump pressure.

To adapt the working width gravure coating systems can be equipped the backing rollers in sleeve-type design. Sleeve change sequence takes about 3 min.

Curtain dies needs to reposition the edge units and the deckling. This can be done either manually or by motorized equipment's. With motorized design it will last only a few minutes, if the coating compound does not influences the deckling parts.

For the contact gravure system a backing roller is required. In reverse mode the quality of the rubber roller (tolerance in roundness) will influence the uniformity of the coating.

For curtain coating this is not an issue.

Due to the **contact application a boundary air layer** on the surface of the web to be coated has no influence for the gravure system.

Curtain coating is much more sensitive. Here the impact of the curtain is required to destroy the boundary air layer. On higher production speeds this impact needs to be supported by vacuum unit (nozzles with fan etc.).

A sophisticated pressurized chamber system with tool free exchange of blades and baffle system is easy to be disassembled and to be cleaned. With according side equipment with second circulation system (pump, tank, filters etc.) also for different coating compounds a re-start of production is possible just with a short down time.

Due to the more sensitive die equipment the cleaning procedure for a die is more complicated. Equipment needs to be treated much more carefully to avoid any defects like scratches etc. The total cleaning process with disassembly, cleaning and re-assembly could last hours.

If a new compound doesn't contaminate with the used slurry and a second pump with tank can be used, the down time can be reduced (cleaning of the die by flushing with the new compound).

Due to the contact operation the gravure coating systems needs the regular overhaul or replacement of backing rollers. Also the in- and outlet blades and the side sealing's needed to be exchanged regularly because of wear. Screen roller should have a much longer life time.

In comparison the non-contact curtain coating systems needs very less wear parts, for example for the edge units.

If we compare the delivered coating system we see a much higher amount of pressurized chamber units than curtain coating units.

The mentioned price indication might be a reason, also the required modification of coating compounds. This modification requires technological expertise and might result in cost and time effective evaluation processes.

Cost drivers for the curtain coating stations are the quality of the die (grade of manufacturing), the vacuum unit (boundary air layer) and the more extensive circulating system (degassing).