Curtain Coating - Minimizing Efforts for Development

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Extended Abstract:

Key words: premetered coating, curtain coating, development

Introduction

Premetered coating in the curtain format is an attractive method to apply single or multilayer structures of functional layers to continuously running substrates.

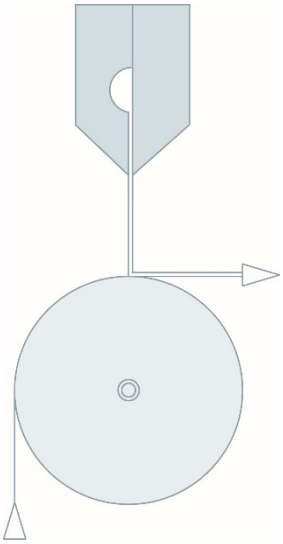

Figure 1. Single layer curtain slot die

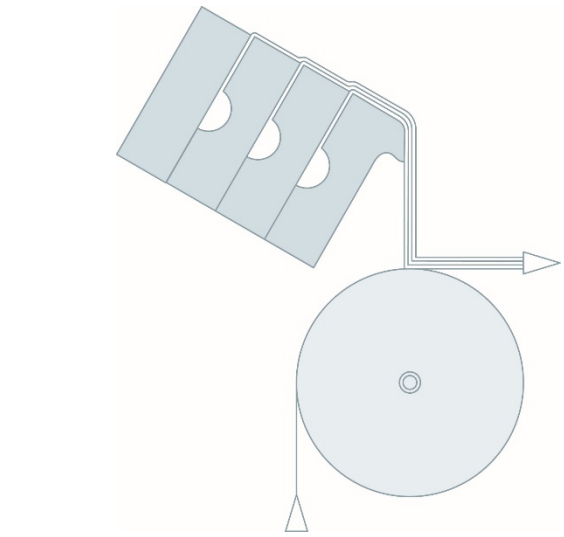

Figure 2. Multilayer curtain slide die

This technology has been developed in the photographic industry several decades ago and was used in this field for a long time successfully in the multilayer mode. Since the mid 1990's curtain coating was introduced in the field of PSA labels as well as in specialty paper applications such as digital imaging or thermosensitive paper. More recent applications use curtain coating in the field of paperboard coating or with barrier coatings e.g. for food packaging.

The main advantages of premetered coating methods in general are the following:

- Coat weight or film thickness is specified within operating range of process
- Formulation changes do not affect average coat weight
- Reactive liquids (multi- component) systems can be coated
- Multiple layers coated simultaneously

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- Excellent uniformity of coated film in both, cross-web and machine direction
- The coating process can be scaled up from R&D over pilot to full production scale

Curtain Coating as one family member of the premetered coating methods is the only technology capable to run with speeds of 1000 m/min or way more, which are typically used in the paper and PSA industry.

Especially coating with a multilayer curtain die offers the possibility to split a rather thick layer of expensive coating liquid in one part of inexpensive filling material and a second part of the sophisticated coating liquid. This option actually becomes more and more attractive in the field of Pressure Sensitive Adhesive (PSA-) labels in order to be more efficient in terms of raw material cost. Other options with multi-layer curtain coating are combining layers for process and product optimization, achieving very thin individual layers or structures, which could not be produced with single-layer modes, or "just" increasing the efficiency of a production process.

Curtain Stability

Running a curtain coating process successfully means at first to fulfil the limit of a stable curtain. This requires a certain minimum flow rate, which is mainly depending on fluid properties and flow rate. Knowing this minimum flow rate is crucial in order to calculate the minimum coating speed when the desired wet coating thickness is selected. In particular when the coating thickness shall be low the speed needs to be rather high. Determining the minimum flow rate typically is the first step when starting development of a new product for curtain coating. By fine-tuning the coating liquid, the limit of a stable curtain can be influenced positively. Therefore a static trial is sufficient by dropping the liquid curtain into a pan while recirculating the liquid. When running the curtain the dynamic surface tension can be determined by measuring the "Mach-Angle" (red line). A needle intruding in the curtain (see Fig. 4) creates a standing wave, with an appropriate device, the opening angle between the waves can be measured and the dynamic surface tension can be calculated using different liquid and flow parameters.

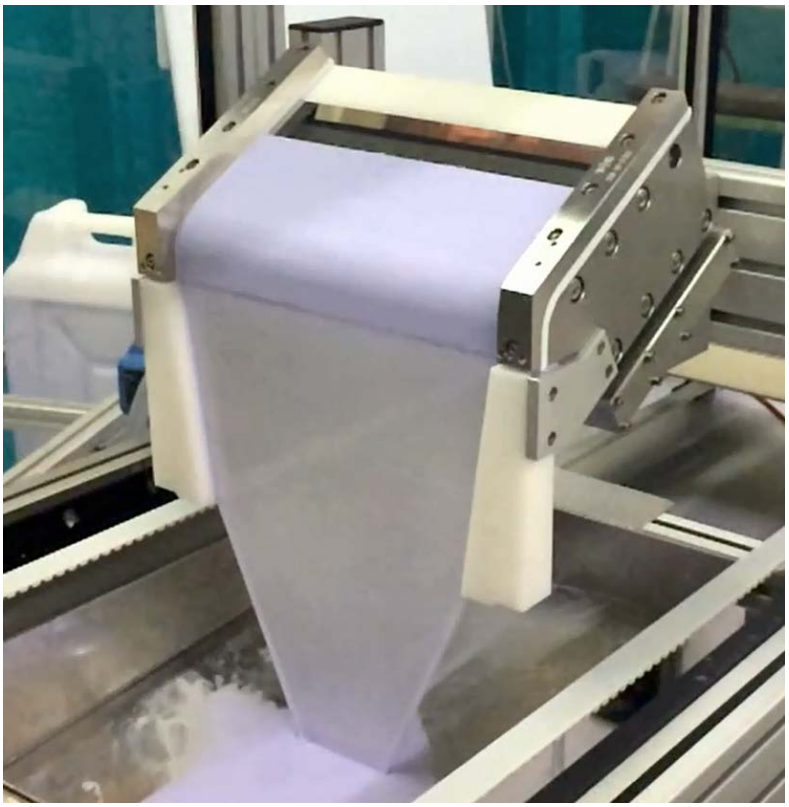

Figure 3. Falling curtain on multilayer-slide die

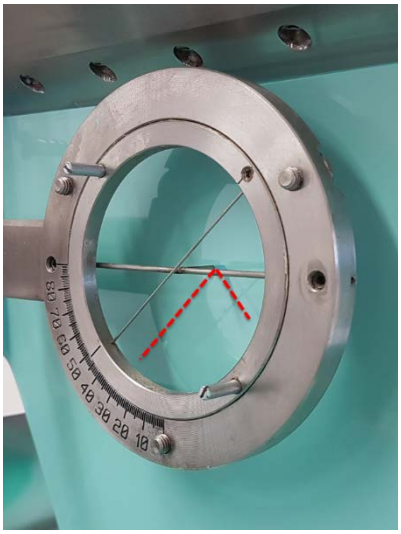

Figure 4. Mach-Angle measurement [1]

In order to achieve minimal low-flow limits the surface tension should be below a maximum value of 40 mN/m, but not only the dynamic surface tension, also a certain viscoelastic behavior influences the curtain stability positively.

Pilot Trials

Curtain stability is surely the biggest limit to overcome, but the coating performance depends on different other parameters as well. Therefore running coating trials under the intended operating conditions and on the target substrate to be coated is crucial. Especially when different variations of the same formulation shall be compared - all applied under the same conditions, it is beneficial having access to a narrow pilot line.

Running pilot trials on a roll-to-roll (R2R-) machine for product and process development the rather high speeds result in high consumption of raw materials namely of substrate and coating liquid. Typical pilot machines for example in the paper or PSA industry are over 0.5m wide, and for one coating trial often several thousand meters of substrate and maybe hundred liters or more of coating liquid are consumed. Also cleaning of such a machine at the end of a coating run and for changeover between different formulations is consuming time and human work force.

When comparing different formulations or variations of one coating liquid a longer trial on a pilot line with the most promising mutation usually is needed, but in order to select the versions with good prospect it is time and cost saving to run the selection process on a machine needing only a small amount of materials.

Coating trials with minimized used of resources

One possibility is to coat a few samples on a sheet-based (S2S-) coater in order to compare the variations. Such an operation only requires some sheets of the substrate to be coated on and a rather small amount of coating liquid in the order of 10-15kg per formulation. Coating can be applied either in a single or in a multilayer mode. An example of such a sheet-based coater is shown in the following picture.

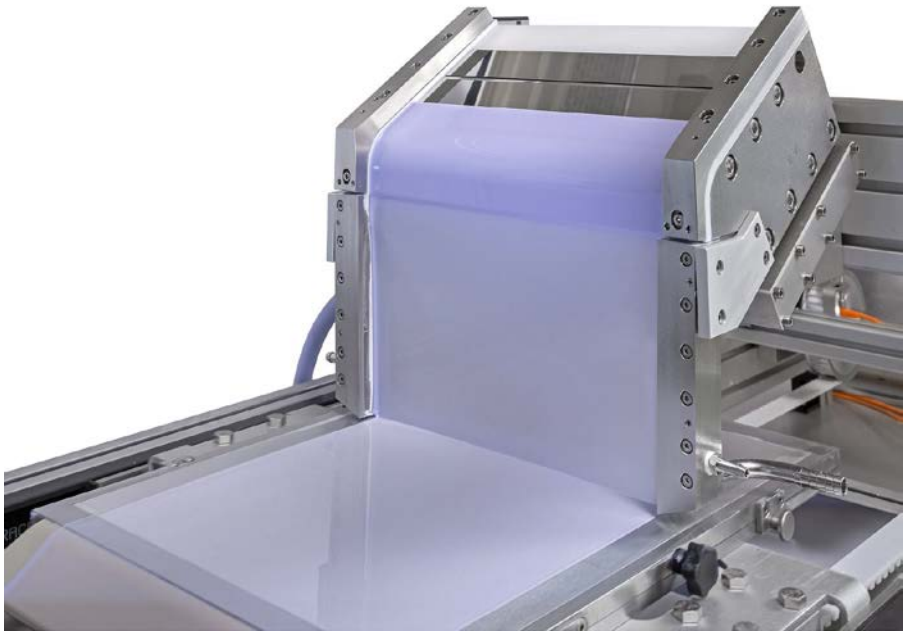

Figure 5. TSE TableCoater for curtain coating in operation with single layer curtain on multilayer-slide die

In such a machine setup, it is possible to run several variations of one formulation per day in order to select the most promising one. Even when the coating and drying conditions are not exactly the same

compared to real-life experiments on a R2R- machine, it is possible to compare the different variations between each other.

A second possibility is to use an endless belt of substrate and to coat on this just for a very short time in the order of a few seconds, depending on speed and belt length. The coating operation can also be either single or multilayer and the drying can be very simple or more sophisticated, depending on the needs.

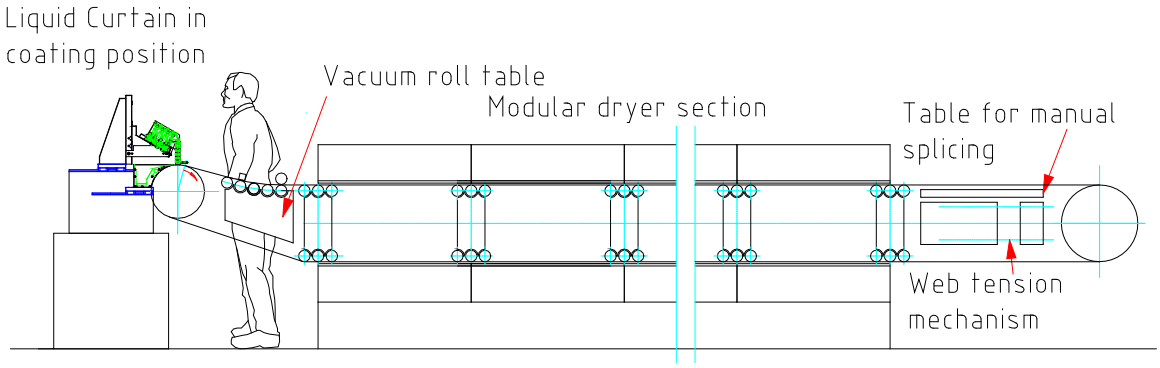

Figure 6. General machine layout of loop machine for curtain coating

The advantage of the sheet-based setup is that the curtain can be stabilized and the running table does not disturb the curtain, when the shape of the table has been selected appropriately. The maximum speeds at the moment are going up to 600 m/min.

The advantage of the loop-coater is that the length of the coated sample is a few meters and the coating conditions are closer to a R2R- process. Nevertheless, the time for the real coating run is very short too and therefore the maximum speed is somehow restricted as well. The footprint for a loop-coater capable to run 600 m/min for example is much larger compared to a S2S- coater.

Both options are available for tests, the coating width is in the order of 0.25m to 0.3m. First compatibility tests in multilayer systems can be applied as well as determining the minimum flow rate respectively coating of samples finally. Therefore both options are versatile and flexible and help to secure cost-efficient development of future-orientated products.

Summary

1. The single- and multilayer- curtain coating methods are well known and understood and combine all advantages of premetered coating methods with an optimized production setup
2. Multilayer structures help to optimize the functional performance of the product as well as the economics and the technology of the production processes
3. These methods require thorough planning and preparation for a successful implementation
4. Coating trials using pilot machines are cost-efficient and beneficial.
5. Trial machines using a sheet-based setup or coating on an endless belt (loop- coaters) help to save time and workforce in the selection of the most promising coating formulation, before running a longer trial on a R2R- pilot machine.
6. Both machines cannot substitute the fully equipped R2R- machines, but they can support the process and help to save resources.

References

[1] Mach- Angle measurement device by Polytype Converting AG, Switzerland

Examples

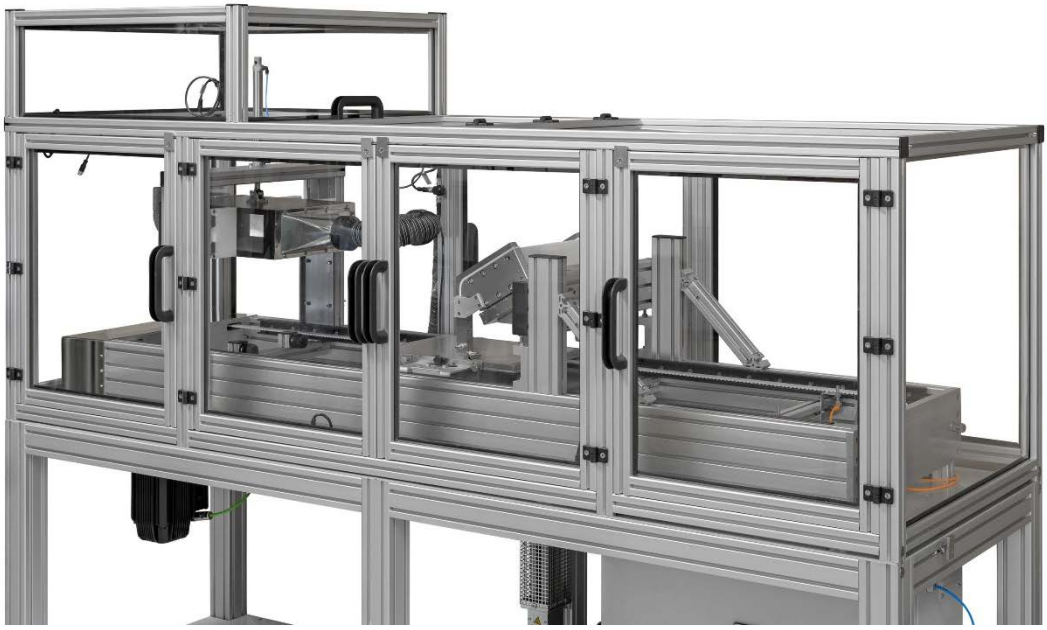

Figure 7. TSE TableCoater for curtain coating [TSE Troller AG, Switzerland]

Figure 8. DEXMA Loop- machine for curtain coating [iPrint institute, Switzerland]