# Batch drying of thin films under industrial process conditions

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## Introduction

The properties of functional films, coated as wet film and subsequently dried in continuous roll-to-roll processes, often depend on the drying conditions. During drying, the film solidifies and the final internal structure develops. Research on the drying step is often conducted in small scale batch processes to minimize costs or due to limited amounts of new materials. For an accurate interpretation of experimental data and a scale-up to production conditions, a very precise control of the boundary conditions over a wide range of drying rates is important. For this contribution, a set-up for batch processing of thin films with a coating length of up to 0.75 m was optimized and characterized.

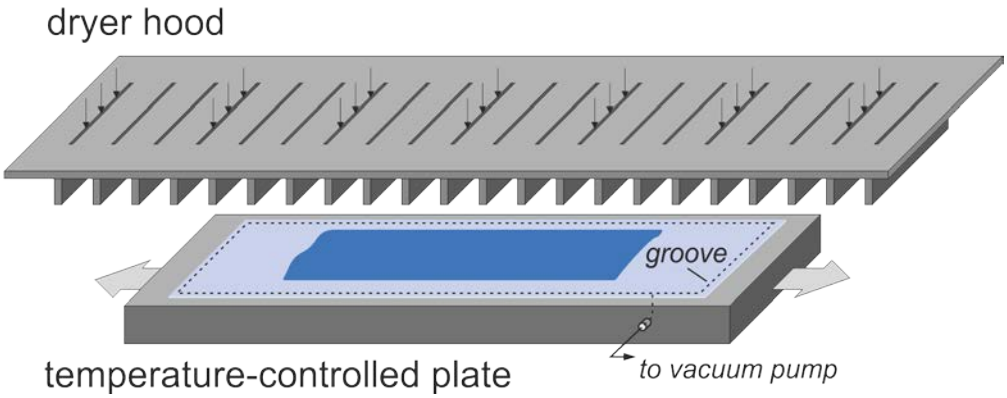


*Figure 1: Schematic drawing of the experimental coating and drying set-up consisting of an impingement dryer hood with a moving, temperature-controlled carrier beneath the dryer. Thin air films between substrate and plate are prevented by applying vacuum via a groove.*

Figure 1 shows a schematic drawing of the set-up. It consists of an impingement dryer which enables high gas phase mass transfer coefficients and reproducible drying conditions. Gas and substrate carrier are heated to the desired temperature. To ensure a good thermal contact between substrate foil and substrate carrier, a vacuum can be applied via a groove. After coating with a knife coater or slot die, the

film is dried under the impingement dryer at gas phase mass transfer conditions comparable to industrial drying conditions. Homogeneous lateral drying rates are achieved by a periodical relative movement between dryer and substrate carrier.

## Experimental methods and results

The set-up was characterized by means of measuring heat transfer coefficients, nozzle outlet velocities and film temperatures during drying of water- and solvent-based coatings.

For determination of heat transfer coefficients, a temperature difference between impinging gas flux and the plate was set and heat flux $\dot{q}$ at the plate beneath the dryer was measured by a commercially available heat flux sensor (dimensions: 8.5 x 8.5 mm).

$$\dot{q} = \frac{\dot{q}}{(T_g - T_p)} \qquad \text{Eq. 1}$$

Gas temperature $T_g$ at the nozzle outlet and substrate temperature $T_p$ were used to calculate heat transfer coefficients according to Eq. 1. The dryer was characterized by moving the measurement set-up slowly with a velocity of 0.1 mm/s.

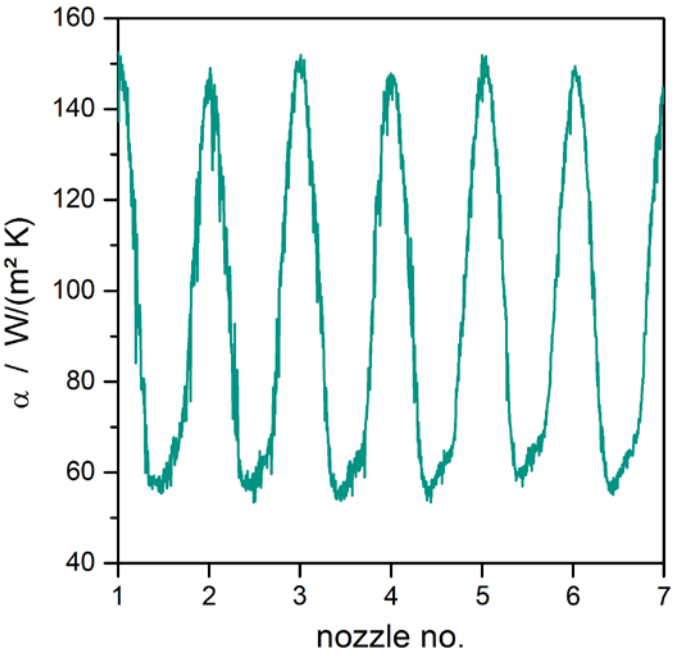


*Figure 2: Local heat transfer coefficient calculated from heat flux and temperature measurement.*

Figure 2 shows exemplarily the local distribution of measured heat transfer coefficients for the highest nozzle outlet velocity. Averaging over the whole measured range gives a mean heat flux coefficient of 93 W/(m² K) for this condition.

The results allow for calculation of drying rates and the systematic, independent variation of drying rate and drying temperature.

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