Impact of the local distribution of the heat transfer coefficient on the properties of thin porous films

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Impingement drying represents a standard drying process in continuous manufacturing of thin, functional films. Apart from production-sized plants, lab-scale impingement drying units are deployed in academic research. These smaller set-ups usually run at rather low web speeds, since the dryer capability is limited due to the rather short dryer. Especially for thick films or films containing solvents with a high boiling point, the inhomogeneity associated with nozzle dryers can impact the film properties, when the web speed falls below a critical value.

In this work, a drying unit consisting of a temperature-controlled plate carrying the specimen to be dried and a dryer hood providing an array of slot nozzles, was characterized regarding the distribution of the heat transfer coefficient (*Figure 1 – Distribution of the heat transfer coefficient α W/m²K as a function of the position in the dryer.*). As expected, it becomes obvious that stagnation areas, which are located under each nozzle, are governed by high heat transfer coefficients, whereas dryer positions between two adjacent nozzles provide lower α values. This inhomogeneity, usually of no consequence, starts carrying weight for slow relative movement speeds of the drying film.

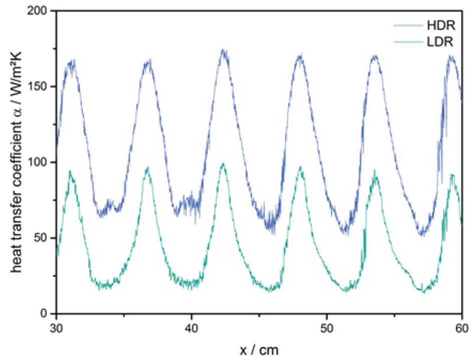

Figure 1 – Distribution of the heat transfer coefficient α W/m²K as a function of the position in the dryer.

Based on the available knowledge concerning the existence of a critical time period during drying (as illustrated by the author within the framework of another abstract submission), an experimental approach was chosen, which allowed for identifying the dependency of film properties on the web speed or, rather, the local distribution of the heat transfer coefficient during drying. The material system comprised graphite particles (>90wt.-%), carbon black, a binder and a solvent.

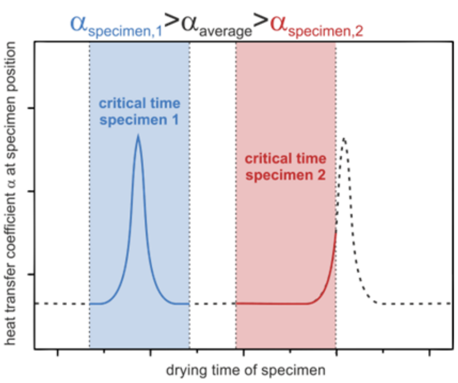

Figure 2 – Schematic drawing of HTC profiles for speciment dried at different positions within the same coating.

Films were coated and dried at dryer set-ups providing the same average heat transfer coefficient and, therefore, identical drying boundary conditions. Surprisingly, it could be shown that different specimen of the same coating strongly varied with regard to their properties, depending on the α-distribution prevalent in the critical drying period. The specimen’s adhesive force, obtained from a 90° peel test, was consulted as a measure for binder concentration at the interface of active layer and copper substrate.

These findings further reinforce the significance of the critical drying period presented by the author in another contribution and might be of special interest for researchers preparing films in smaller lab-sized plants.