Simulation to design technical film drying processes

P. Scharfer, W. Schabel and **M. Kind**

Institute of Thermal Process Engineering, University of Karlsruhe (TH)
76128 Karlsruhe, Germany

Drying of coatings plays an important role in the production of many high-quality products. Dissolved coating components are applied on a substrate and subsequently dried. As examples foils for LCD-flat panels as well as photo and varnish films or transdermal patches can be listed. Drying often determines capacity and quality aspects of the coating process.

In order to design such processes, model calculations and simulations are necessary. The model approaches which have to be used to simulate a complex drying process are briefly shown in Figure 1.

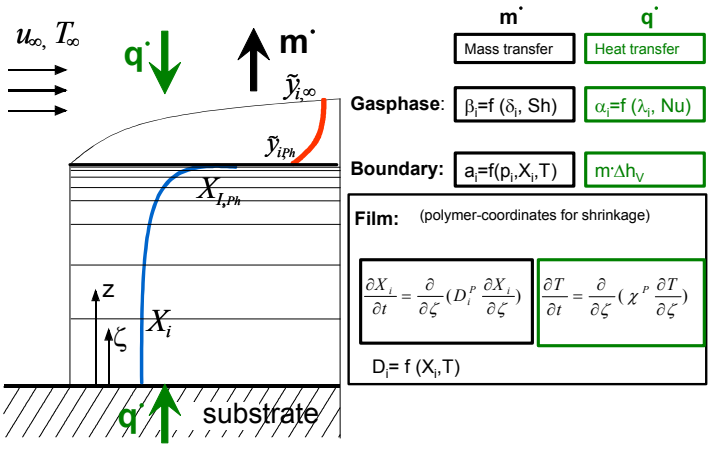
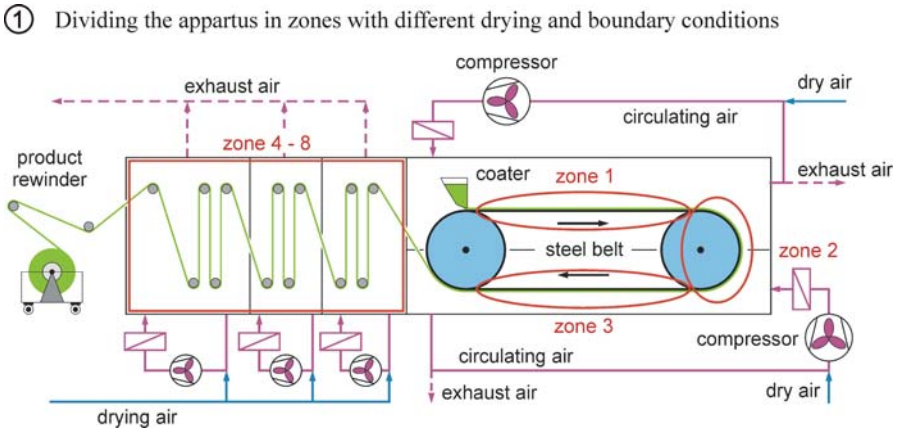
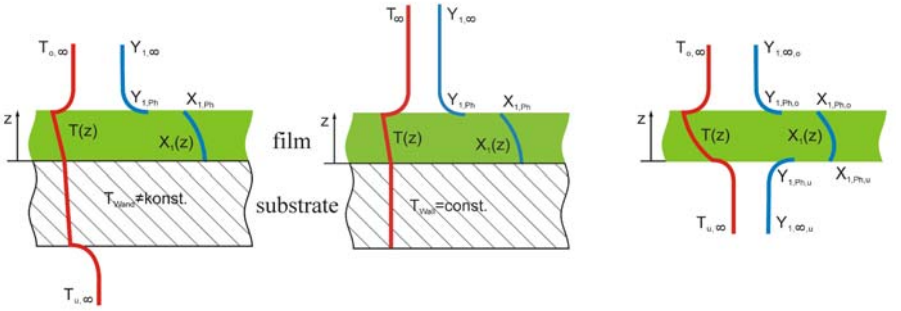


Figure 1: Simulation model to predict the drying process of thin polymeric coatings in technical dryers.

Based on this general model, the simulation software NuSFiD© has recently been developed to simulate technical drying processes in a modular concept. A complex apparatus is divided in as many zones as necessary where different drying and boundary conditions are existent. Heat and mass transfer balances in each zone provide the gas phase and liquid phase properties, i.e. temperature and moisture of the drying air and the coating, at each position in the dryer. The different steps to simulate a drying process in a technical belt dryer as an example are shown in the following scheme (Figure 2).



② Definition of boundary and initial conditions of temperature (T), gas phase (Y) and liquid phase composition (X) to solve the mathematical differential equations for heat and mass transfer in the film in each zone.



boundary conditions (zone 1+3)
heat transfer from both sides
mass transfer to one side

boundary conditions (zone 2)
heat transfer from both sides
constant substrate temperature
mass transfer to one side

boundary conditions (zone 4-8)
heat transfer from both sides
mass transfer to both sides

③ Sorption isotherms data and diffusion coefficients have to be obtained from laboratory measurements by fitting to model calculations.
Gas side heat and mass transfer coefficients are calculated from Nu, Sh-correlations or are directly measured in the apparatus by means of gravimetric sublimation expermients.

④ Simultaneous mathematical solution of temperature and concentration profiles in the film. The results of the calculations at the end of each zone provide the initial conditions for the calculations in the next zone.

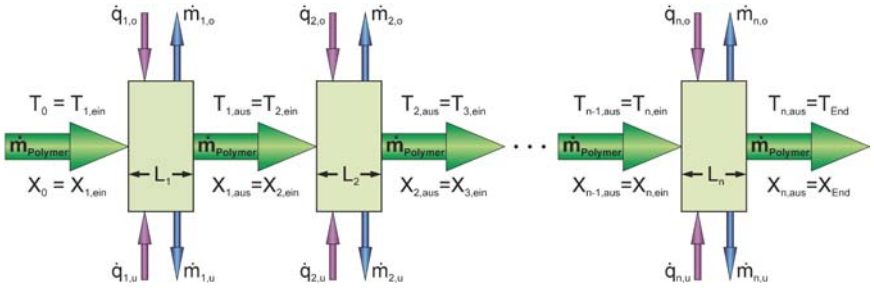


Figure 2: Principle steps to simulate complex technical drying processes modular and systematically with the simulation software NuSFiD©, developed at the University of Karlsruhe. Contact persons: scharfer@tvt.uka.de and schabel@tvt.uka.de

The program is especially designed to calculate drying processes in industrial applications. It is built up modularly and therefore very flexible for different types of mass transport simulations. The simultaneous solution of coupled partial differential equations to describe heat and mass transfer in polymeric systems is performed by special NAG FORTRAN solvers, which are implemented in a VISULAL BASIC source code.

It could be shown, that there is a huge potential for optimizing technical belt dryers by means of the simulation software NuSFiD©. By setting up an ideal temperature distribution, a suitable gas phase preloading and the best flow rates for adequate outer heat and mass transfer, in some cases it was possible to decrease the drying length to less than 50 % from its initial length.