Thesis title: **Mathematical Modelling of Wet Paper Pressing**

Thesis summary:

In the press-section of a paper machine, the wet paper, together with one or two felts, passes through a press-nip formed by a pair of (sometimes preheated) press rolls, or a single roll and a shoe. Water is squeezed out from the paper into the felt(s) by applying a sharp pressure pulse. Even a small improvement in the efficiency of the press-section may lead to significant reductions of production time and costs. Limitations of experimental approaches (high machine speed, small paper thickness), motivate theoretical approaches, in particular: modelling, analysis and computations.

In this thesis several mathematical models for wet paper pressing are derived and studied. Following scaling arguments, we adopt a one-dimensional transversal approach. The theory for multiphase (water, air) flow through deformable porous media (paper, felt) is applied. The elastic, visco-elastic and plastic paper defformations are taken into account. The resulting model, consisting of mass and momentum balance equations and state equations, is mathematically rewritten into a system of two partial differential equations in terms of scaled void ratio and water saturation. With different parameters this system is valid both in the paper and in the felt domain. At the paper-felt interface, corresponding cross conditions are prescribed.

In the specific case when layers are completely saturated by water, the model reduces to a single, nonlinear diffusion equation with cross conditions, allowing detailed mathematical treatment. In particular, existence (method of regularization), uniqueness (comparison principle) and some qualitative properties of the solution (maximum principle) are shown. In the general case, the system is, by means of a suitable transformation, rewritten into a parabolic-hyperbolic form. This form explains why shock-like behaviour of water saturation is to be expected, suggests types of boundary and cross conditions which should be prescribed and motivates specific numerical approaches. In particular we use a shock capturing (saturation-upwind) and a shock tracking method. Modeling the hot paper pressing (drying of paper using the combined action of pressure and heat) is achieved by adding a heat equation to the standard system, with suitable coupling in the coefficients. The resulting model is computationally treated using a generalization of previously established approach.

Comparisons with the results of other models and experimental observations show that the proposed models give good qualitative description of the wet pressing process. Known sub-phases of the press-nip are well reproduced, and insights into influence of certain phenomena (plastic paper deformation, presence of air in the pores, application of heat flux through the rolls) are gained. These properties recommend the proposed models as useful tools for understanding and optimizing of the wet pressing process.