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Application of contact mechanics to paper transport in copiers and printers

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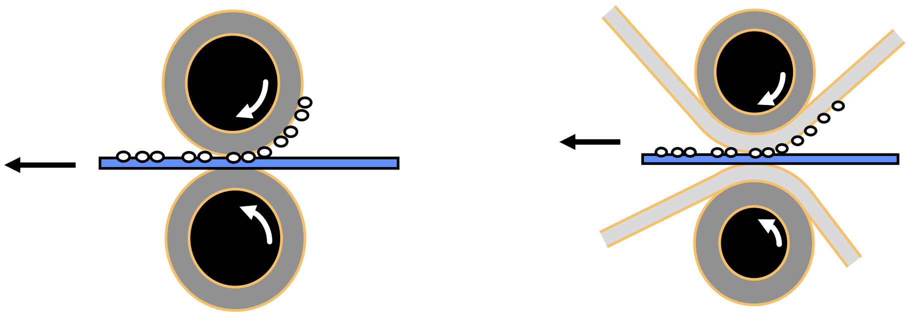
1 INTRODUCTION, COPIER NIPS AND CONTACT MECHANICS

In copiers and printers the most important contact is the one between the two fuser rollers. In the nip between these rollers the toner-image is pressed into the paper at elevated temperature and pressure. The rollers may be coated with relatively thin and soft rubbers, fig. 1a, or belts are fed between the rollers,
fig. 1.b. The design of the fuser nip has to be chosen such, that various requirements are met. One of these is the prevention of paper wrinkling. In this contribution an example will be presented of the application of contact mechanics simulations to explain a specific cause of paper wrinkling that may occur in a fuser nip of the type in fig. 1b.

The application of contact mechanics for the study of transport phenomena in copiers and printers is wide-spread. Apart from Kalker several other authors have developed simulation tools that have been used for the study of the transport of thin media through nips, both semi-analytically or using FEM-codes. Semi-analytical approaches have the advantage that they result in relatively fast simulation tools. However, the configurations that can be studied have to meet the conditions that are imposed by approximations that are part of their foundations. FEM-codes can be applied for a wider range of configurations, but they lack the speed of the specially designed tools.



(a) (b)

Fig. 1. Two different configurations for fuser nips in copiers and printers. In (a) a nip formed by two rubber-coated rollers is shown, in (b) a configuration with 2 belts between rubber-covered rollers.

2 CAUSES AND PREVENTION OF PAPER WRINKLING

The occurrence of paper wrinkling in printers is an annoying phenomenon and therefore counteracted by various measures. The design of the fuser nip is important in this respect, especially in wide-format printing. Paper wrinkling can be caused by differences in the paper transport speed along the axis of the rollers. These differences can arise from the bending of the rollers due to the nip pressure. This leads to an inhomogeneous distribution of the pressure along the roller axes, leading to differences in creepage and thus in paper speed. If the paper speed at the edges of the nip tends to be higher than in the centre, wrinkling may occur. The nip must therefore be designed such that the paper speed is higest in the centre.

3 SIMULATION TOOLS

For nips consisting of 2 rubber-covered rollers the simulation of the 2D rolling contact behaviour is rather straightforward using semi-analytical codes as the ones that were developed by Kalker. Nip width, peak pressures and creepage can readily be calculated. Especially creepage can be used to predict the paper speed in the nip.
However, the design of fuser nips requires knowledge of the 3D-nip contacts as in fig. 2: a combination of the 2D-rolling contact and the bending of the rollers. So far, no semi-analytical 3D-solutions exist for such configurations. For instance, Kalker's 3D-contact tools cannot be used in this case because of the line-like shape of the contact region.

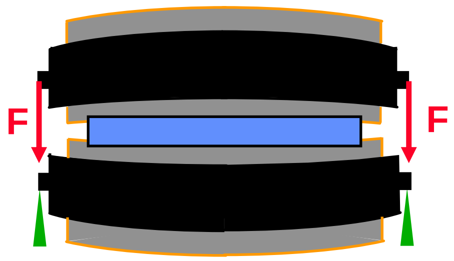


Fig. 2. In copiers and printers it is also important to have knowledge of the 3D-contact problem arising from the combination of the 2D-rolling contact and the bending of the rollers.

Therefore the variation of the paper speed along the axes of the rollers must be estimated from a step-by-step approach.

First the nip stiffness is determined from a set of 2D-simulations. Fuser nips as in fig. 1.b, however, comprise several contact-planes and no semi-analytical methods exist for the simulation of such nips. A FEM-code has been used instead.
Subsequently the interaction of the rolling contact and the bending of the rollers is modelled with a seperate simulation tool, developed under supervision of Kalker.
The pressure distribution can then be translated into an approximation of the creepage distribution and used to predict the probability of paper wrinkling.

In practice it is found that nips with belts may show differences in paper transport speed for various reasons. One of these, occurring in nips of the type in fig. 1.b will be treated in this contribution.