

# Cockle Formation in Coated Magazine Paper Production

*What the data show about the causes and prevention of unwanted wrinkles.*

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**T**he cockle phenomenon is known to occur during the production of some lightweight papers such as coated magazine paper [1]. Cockle are represented by machine-direction-oriented wrinkles, usually much longer than wider, that occur on the paper surface. Cockle are unwanted, as they cause serious quality problems in the finishing sections (supercalender) of the paper machine. When the amplitude of the wrinkles with respect to the paper sheet plane is high, the cockle overlap when the paper is passed between the supercalender rolls. Thus, cockle create areas on the paper with uneven structure representing serious printing problems.

Some studies on cockle formation exist, but there are no fundamental models from which to predict the onset of cockle. This lack is not surprising since the fundamental knowledge needed to develop a phenomenological model of cockle is sparse. An alternative approach is to develop an empirical model using hierarchical multivariate statistical methods from the large amount of data that can be obtained when cockle is present.

The hierarchical approach has been used in other applications such as process monitoring [2] and spectroscopy [3]. Multidimensional decompositions have also been applied to batch processes [4], [5], spectroscopy [6], and chromatography [7]. One of the differences between the present study and others is that continuous process data

are analyzed as batch data (see "Preliminaries").

In the present work the primary target is the discovery of the important factors that lead to cockle formation. In standard applications, all outlying data are removed from the calibration data set. Here, such data are preserved in the data set deliberately, as they may provide information to detect the root cause of cockle. The exception are those data that result from sensor malfunction or data collection problems.

## Preliminaries

### **Paper Machine Structure**

The production of the paper reel takes place on the paper machine. The paper machine performs three main processes: stock preparation, wet end, and dry end. Stock preparation includes the preprocessing of all the different fibers and the addition of additives to produce different properties, for example, printability. In the beginning of the wet end process, fiber suspension is fed on a moving web where water is drained to form a wet paper sheet. This sheet is then pressed to remove water and achieve certain physico-mechanical properties. In the dry-end section, the paper passes through a series of rotating cylinders (dryers), some of which are internally heated by steam. Between the dryers, other equipment such as calenders and coaters may apply additional