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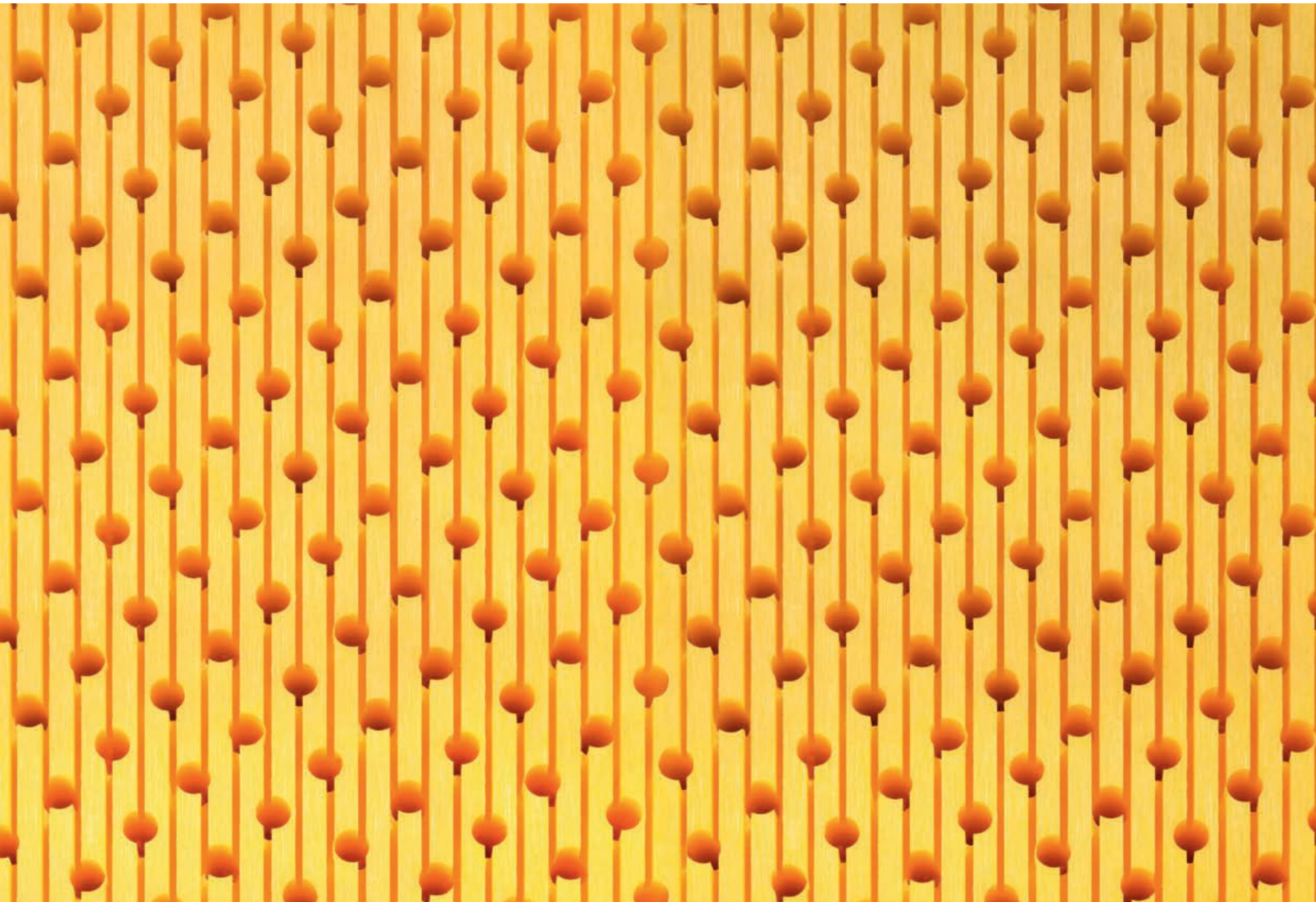
How the surface design of suction and press rolls affects dewatering in the press section



The first Fourdrinier paper machine was invented by Frenchman Nicholas-Louis Robert in 1799. Ever since paper manufacturers have wanted to improve the dewatering process. Numerous theories and models have been developed for press nip dewatering. A new concept exploits the surface design of suction and press rolls and comprehensively analyzes optimum dewatering characteristics.

Dewatering in the press section

The main function of the press section is to dewater the fiber mat by means of mechanical pressure. The dry content is increased in the presses before the paper web is transferred to the dryer section. The higher the increase in dry content out of the press section, the less drying energy is needed. This makes the paper manufacturing process more efficient and cost effective. This is reason enough to make the dewatering of the paper web as efficient and effective as possible.

NipMaster analysis program for optimum dewatering

In the last few decades, Voith has conducted studies and trials on pilot and customer machines in order to investigate the surface design of suction and press rolls and their influence on the dewatering process.

One outcome of this ongoing research is the NipMaster analysis program. Tailored to the respective operational position and its requirements, NipMaster allows press impulses, specific pressures and dwell times to be calculated. At a high level, this helps identify deficiencies in dewatering. In addition, NipMaster can analyze flow paths, and optimizes surface designs to help address sheet quality like marking.

Various parameters affect dewatering performance

There are a number of variables that have an impact on the dewatering process. All should be considered. These variables include the surface geometry and distribution, furnish, and the design and conditioning of roll covers and clothing. The wide range of fibers in the industry is presenting new challenges in the press nip by increasing the structural resistance to flow. The press impulse is the basis for counteracting this resistance and ensuring optimum dewatering of the paper web. Many paper machines are identical in their press configuration and mode of operation, but their sheet structure and thus dewatering performance differ. Accordingly, every paper machine has to be analyzed individually and may have unique requirements for quality, hardness and surface characteristics of the covers.

Choice of cover materials for press section

NipMaster allows each roll to be tailored to the application. This includes customizing the cover material. Polyurethane is the state-of-the-art material for roll covers, but rubber and other materials persist in the industry. Many factors come into play when choosing a roll cover material type: paper quality, basis weight range, raw material composition, water retention capacity, freeness, chemical feedstocks, machine speed, press loadings, roll position and the regrind interval. Full understanding of the application is needed to determine the right choice of cover material, because the material choice will constrain the cover hardness and surface qualities.

Another optimization tool offered by NipMaster is the “press analysis” which analyzes the water balance and existing water capacity in the rolls. The press analysis helps optimize suction roll flow paths which influence overall performance and sheet quality.

Mario Neumann

Mario Neumann has been working in the paper industry since 2001. Until 2017, he worked for Laakirchen Papier AG – Graphic Papers and Board and Packaging (formerly SCA Graphic Laakirchen AG). After completing his apprenticeship as a paper technologist in 2005 and subsequent further training as a plant and industrial foreman, Mario Neumann completed his A-levels and a degree in mechanical engineering alongside is job. Now 35, he has been working at Voith Paper in the Fabric & Roll Systems Division since 2018. Mario Neumann is married and has a 4-year-old son.

Suction roll and press roll optimization

The length of the flow path is a key factor in efficient dewatering. It is also crucial for understanding and minimizing sheet marking in the press section. The combination of surface quality, the arrangement of suction holes, blind-drilled holes and/or grooves determines how far the water has to travel before it reaches one of the collection chambers. The shorter the paths to the respective collection chambers, the lower the hydraulic pressure build-up and the more efficient the dewatering performance. Another important aspect is the design of the clothing, which also plays a significant part towards efficient dewatering.

Interplay between clothing, surface design and conditioning

The optimum interplay between clothing, surface design and conditioning always needs to be considered as a whole to achieve the best possible result. For press rolls the surface design can be customized to achieve optimum surface geometries by means of the groove geometry or in combination with blind-drilled holes. However, in the case of suction press rolls the options are limited, as the arrangement of additional blind holes is predetermined by the core hole pattern in the roll core. The groove geometry, however, can be customized.

Suction hole and blind hole markings are the most common kind of hydraulic markings, caused by the size of the suction hole diameters and a limited blind hole capacity. Trials have shown that it is not possible to completely drain a blind hole during each revolution. Although this reduces the operating volume by a considerable percentage, this can be substantially improved by suitable groove geometry. To both keep the void volume in the blind holes consistently higher and also minimize the tendency to marking due to hydraulic pressure build-up, the blind holes need to intersect with the grooves. This allows the water to escape from the blind holes via the groove and makes a constant volume available. The flow paths to the collection chambers are also much shorter. The more even the surface distribution the more uniform the pressure distribution and the flow path of the water under load.

Micro groove designs are another option for making the flow paths much shorter. They also serve to make the pressure distribution in the surface of the cover as homogeneous as possible. Depending on surface design, the open surface can be up to 48 % on suction press rolls and 42 % on press rolls, although the percentage of open area is not a comparative factor for dewatering capacity. As an indicator for dewatering performance the operative volume (ml/m²) of the various surface designs is compared. NipMaster allows Voith to optimize all of the aforementioned parameters providing optimum press performance.

Hydraulic markings: Hole shadow markings

One of the more common quality defects, is shadow marking (see Fig. 1) and can occur in almost all paper grades. The most common method used in the past to deal with these problems was to make the roll cover softer to reduce the specific pressures in the nip. In the case of obvious marks due to blind hole drillings these were removed to counteract hydraulic-based marking. A major drawback of reducing the specific pressure by using softer roll covers was the increase in micro-friction that occurs at each position in the press nip where the peak pressure is highest and the radius of the soft roll the lowest. Constant deceleration and acceleration occur at this point. This results in friction, which can then lead to more extensive wear and in certain circumstances lower service life or fewer possible regrind intervals for the soft press roll covers. If the specific pressures are reduced too much it is possible that the water in the capillaries cannot be made to flow, depending on pulp and water retention behavior. This would effectively decrease dryness out of the press section.

Importance of flow paths for optimum dewatering

The fact that paper processors have quickly developed innovative quality control measures means that marks in paper are increasingly being detected. These modern error detection methods in the paper processing segment help raise quality to a higher level. Due to the ongoing advances in analysis and greater quality consciousness on the part of paper manufacturers, the requirements on efficient and effective dewatering are also increasing. The flow paths on the roll surfaces are calculated by determining how far the water takes at any position to get to the next groove, blind hole or suction hole.

NipMaster visualizes the path taken by every single water droplet is calculated and the resulting average determined. This in turn provides insights into how efficient the current surface design is and how it can be optimized to reduce flow paths. Fig. 2 provides an example view of the flow paths.

The diagrams that follow (Fig. 3 to Fig. 5) show how important the flow paths are. All three surface designs have the same drill hole size and are suction, blind drilled and grooved. These diagrams were generated in NipMaster along with their accompanying flow diagrams (Fig. 6 to Fig. 8).

Design 1 (Fig. 3 and Fig. 6) shows some blind holes that do not intersect with the groove. Here there is a risk of hydraulic overload, since the water can become trapped in the blind hole. In Design 2 (Fig. 4 and Fig. 7) all blind holes intersect with the groove. This is the result of adjusting blind hole diameter and the space between holes. In Design 3 (Fig. 5 and Fig. 8), the groove was made narrower and the blind hole diameter increased.

Calculating various flow path constellations makes it easier to work towards a more efficient design for mark-prone positions, while of course considering all other parameters in the press nip. The more analyses are done, the better critical values can be narrowed down. From the current perspective, it is very often marginal differences in the design that determine whether there are marks in the paper structure or not. Voith's development of NipMaster has been critical in this research.

Fig. 1: Hole shadow marking

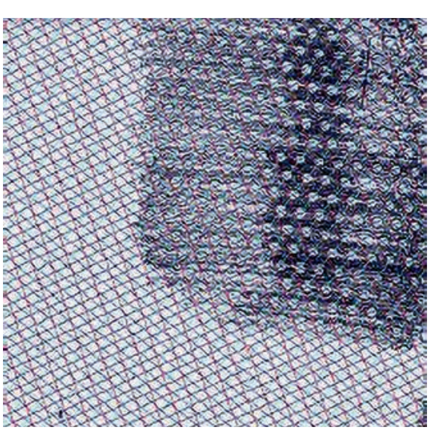


Fig. 2: Flow path of water

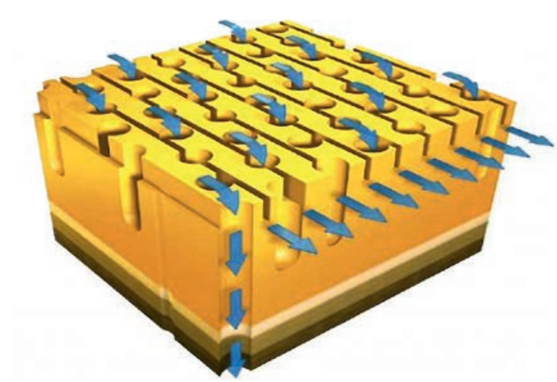


Fig. 3–5: Mean flow path

Design 1 | Design 2 | Design 3

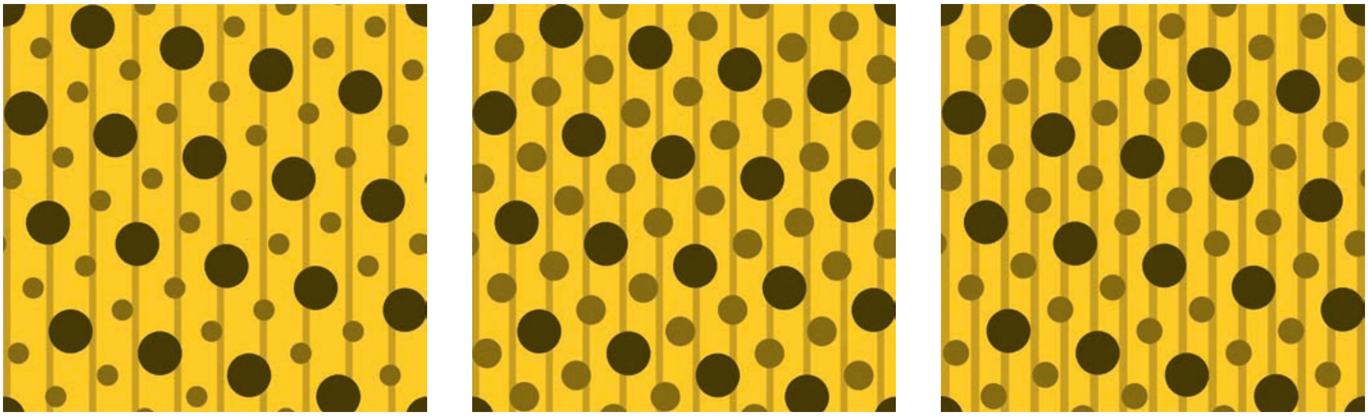
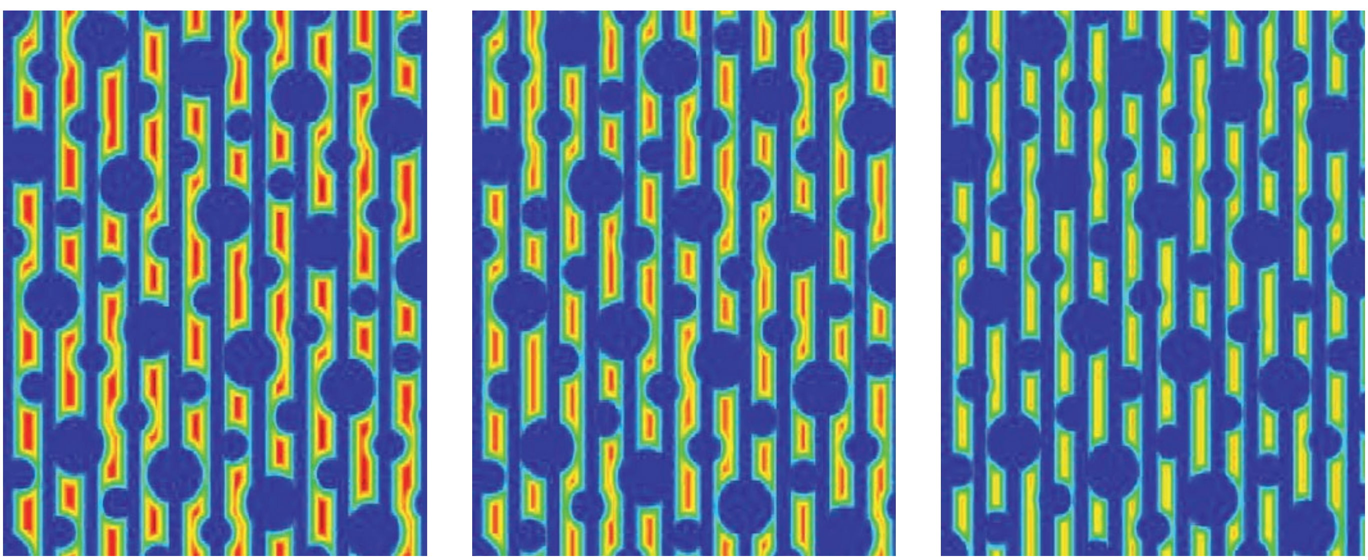
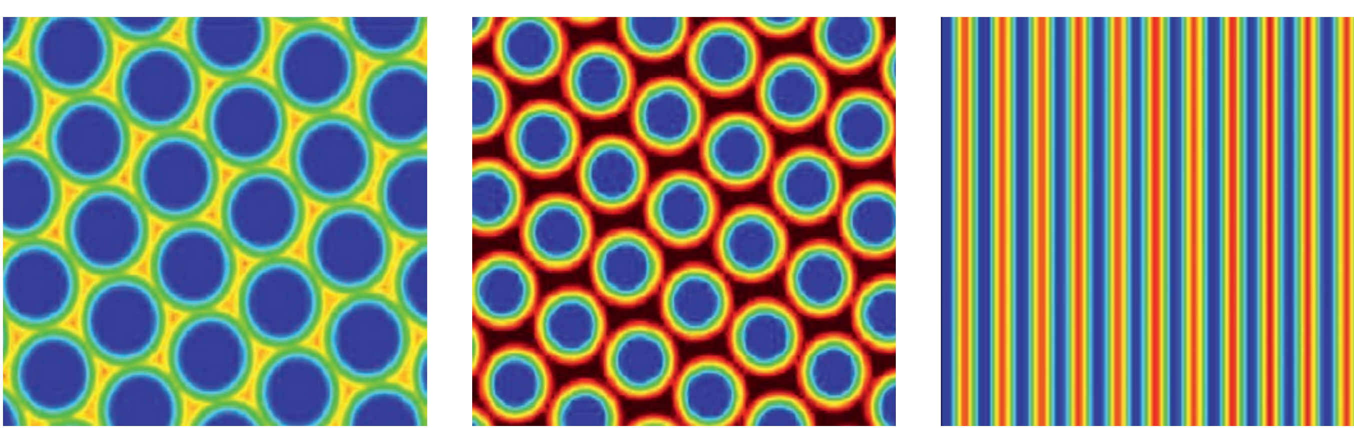


Fig. 6–11: Water flow path diagrams

Design 1 | Design 2 | Design 3



Suction hole design | Blind hole design | Groove design



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