Role of Forming Fabric Surface Topology and Internal Structure Regarding Sheet Quality and Operation Efficiency

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ABSTRACT

This paper takes a look at the modern day forming fabric design trends and their impact on paper quality and paper machine operational efficiency. The focus of the paper is with the forming fabric surface topology and internal structure.

The sheet support binder class (SSB) of forming fabric is now the most widely used class of forming fabric. Within this class of forming fabric there are a growing number of variants. The plain weave surface topology has become the preferred surface topology in the industry, while the internal structure of the forming fabric is still evolving rapidly.

Optimization of paper quality and paper machine efficiency requires an understanding of the forming fabric internal structures and their impact. Better standard parameterization needs to be developed for the effect of different internal structures on paper quality and paper machine operation.

The forming fabric is the woven medium through which water is drained in the forming zone of a modern paper machine. The surface topology and internal structure of the forming fabric is known to influence the final properties of the paper being produced as well as the operational efficiency of the paper machine. Developments in forming fabric technology have been aimed at these areas and a greater understanding of the impact of surface topology and internal structure has been gained.

Literature Review

Surface Topology

The interaction between the surface topology of the forming fabric the and paper quality with regards to printing is well established. The weave pattern knuckles that interact with the paper web during the forming process create areas of low density, while the holes in the forming fabric surface create areas of high density in the fiber web. These micro density differences (figure 1) in the web have been directly correlated to ink penetration and spread, half dot and skip dot tests and gloss (Figure 2). In older style fabrics, the twill of the fabric weave was significantly visible as a wire mark. Further discussion on this can be found elsewhere. (1)

The Industry seems to have settled on the plain weave as providing the surface topology capable of delivering a uniform sheet density and paper web for the widest number of paper machines and grades.

To minimize the micro-density differences in the paper sheet,

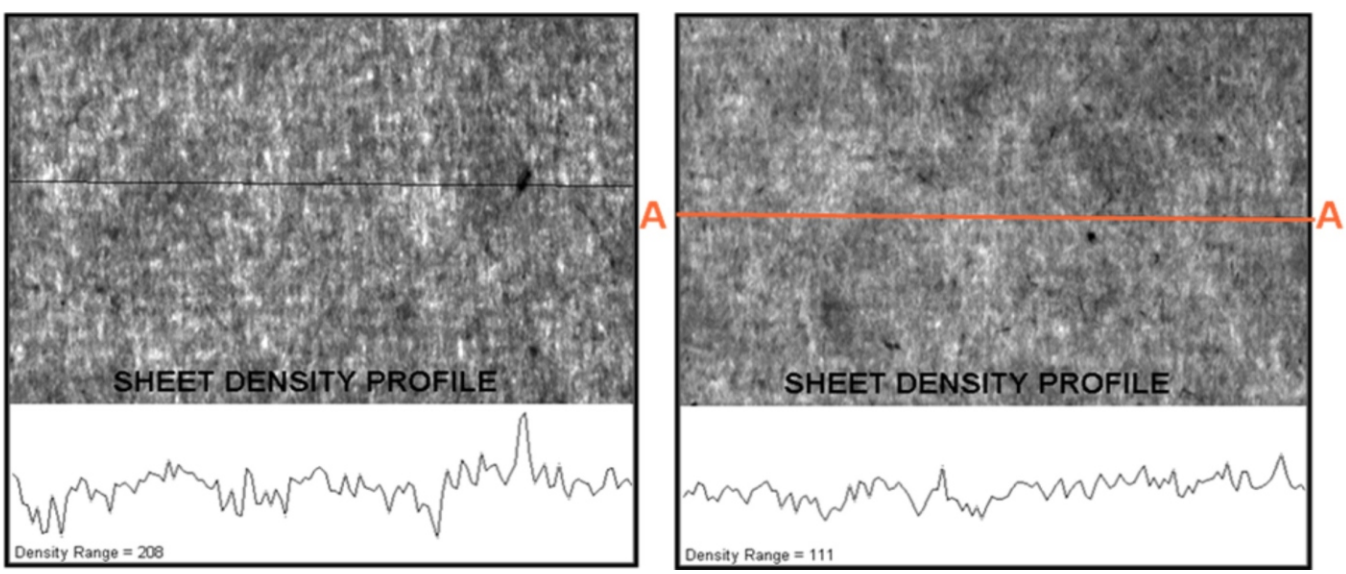

Figure 1. from (1) Numerical evaluation of the printability of paper surfaces

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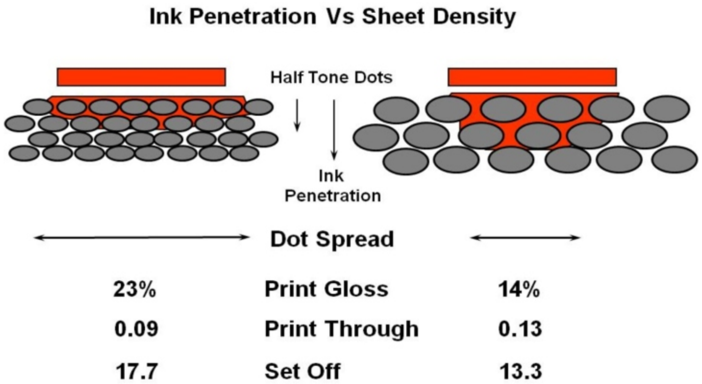


Figure 2. from (1) Numerical evaluation of the printability of paper surfaces

forming fabric surface topology has become finer and finer over the years. The industry has moved from single layer to double layer, to extra-support, to Triple Layer and SSB. Each move in design has increased fiber support index and the fineness of the top surface of the forming fabric. This makes sense considering today's fibers are considerably shorter and especially with the growing recycle content in the Pulp & Paper industry. The SSB fabrics of today use fine yarns and fine mesh which reduces the micro-density differences in the sheet.

Internal Structure

Considerable investment is being made by most PMC suppliers into understanding and getting a hold on the internal structures of forming fabrics. With modern looms (up to 48 shaft) capable of complex weave patterns, the possibilities for engineering the internal structure of the forming fabric have come to life. Three categories of internal structure have emerged in the modern SSB class of forming fabric.

1. SSB (Weft Bound)
2. SSB (Warp Bound)
3. SSB (Warp Intrinsic)
4. Where

SSB (Weft Bound)

Still the most predominant internal structure available today. This structure is very open in the center plane allowing for very fast drainage, The fast drainage means that top avoid fiber embedment, the top surface is very very fine.

SSB (Warp bound)

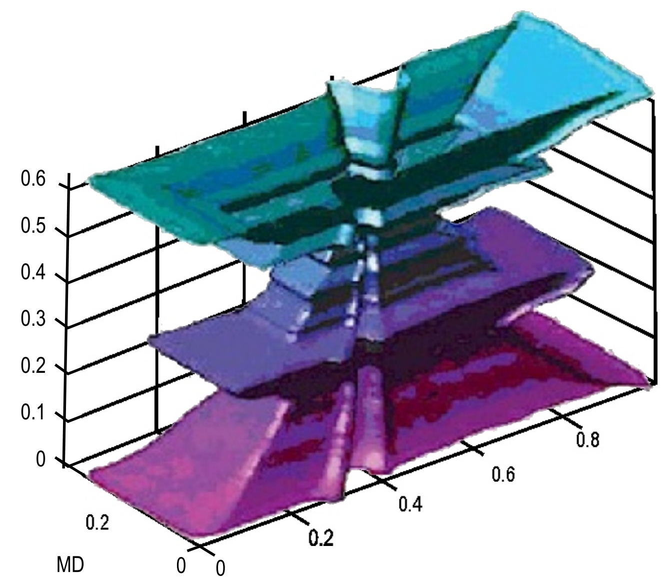
This structure uses the Top MD yarns (warps) to bind the top and bottom layers of the forming fabric together. This structure is very open in the center plane allowing for very fast drainage. Again the top surface is very very fine to avoid fiber embedment.

SSB (Warp Intrinsic)

This structure uses all the MD yarns as part of the Top surface plain weave. This structure is more complex in the center plain and provides a resistance to initial impingement drainage. The slower intial drainage means less fiber embedment, and actually increased drainage past the initial impingement.

The majority of these have plain weave top surface, however, each has a distinctly different and unique internal structure. Within each of the categories there are more variations of 1:1, 2:1 , 3:2, 3:1 different warp ratios, and different weft ratios. These variations in warp and weft ratio also create another level of internal structure differentiation.

Understanding of the impact these different structures are having is growing. The different internal structures are causing different drainage behavior especially with regards to drainage pressure. The very open internal structures provide no or little resistance, while the more complex internal structures provide differing degrees of resistance to drainage pressure. Typically each structure is being quantified as to it's openness throughout it's caliper (z-direction) , as seen in Figure 3.



Fugure 3, from (2) The Impact of Forming Fabric Structures on Print Quality.

Suppliers are trying to quantify an approximation to the drainage pressure resistance. Some suppliers are using empirical methods in the lab to directly measure, water drainage rates, the resistance to drainage, while others are relying on computer modeling. It is evident that the parameters of Open Area and Air permeability are no longer sufficient. There is still some ways to go to come up with a good standard parameter to relate internal structure to paper quality and paper machine operation.

Each category of SSB has it's place. Machine configuration, grade, fiber, and initial impingement drainage pressure will guide applications experts towards one style or another of SSB. Many effects occur due to changes in internal forming fabric structure, and have been experienced in many paper mills. The differences in internal structure in SSB fabrics impact some of the major paper machine operational parameters.

- Fiber usage
- Refining / Furnish mix
- Drive load
- Chemical usage
- Machine Speed
- Downtime / Total efficiency

Some of the significant effects of forming fabric internal structure on paper web quality that have been observed.

- Z-direction distribution of fines
- Smoothness / 2-sidedness
- Mechanical filler retention
- Micro-density profile
- Sheet strength / stability

Conclusion

In order to optimize the paper quality and paper machine operation efficiency the internal structure of the forming fabric must be a consideration. To achieve the benefits from all the forming fabric structures available it is necessary to understand the interactions between fabric structure, drainage, paper quality, and machine operation. This means a close collaboration between the paper makers and the fabric suppliers.

Optimization of paper quality and paper machine efficiency requires an understanding of the forming fabric internal structures and their impact. Better parameterization and industry standards needs to be developed for the internal structure as it relates to paper quality and paper machine efficiency.

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