

„How can a forming fabric reduce the energy consumption in the forming section”

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1. Introduction

On a paper machine, the forming fabric is in contact with the ceramics dewatering elements and creates friction forces and losses of energy. For some fabrics, the loss is quite high and it requires for the paper maker a high drag load in order to run the fabric. Obviously it is a drawback for the fabric. The reduction of drag load of the fabric in the former offers for the papermaker the possibility to reduce the energy consumption in the wet end.

The aim of the experiment or paper is to quantify and identify the different parameters that can affect the drag load of a fabric. This experience then should result in a new forming fabric technology or generation reducing the overall energy consumption in the wet end.

2. Market needs

For the forming section Xerium has put its development focus on a drag load reducing material technology to address two aspects: First, there are many older paper machines, e.g. in the brown paper segment, which are running at the limit of their drive capability. To reduce the drive energy means to secure operation, to optimize costs and to open up opportunities for improving the output by speed increase without investment. Second, on the more modern paper machines which are equipped with enough drive power, reduced drive energy contributes significantly to reduce the production costs.

3. Project

3.1 Project Goals and Targets

On a fourdrinier machine, there are different parts where energy loss can be found:

- Energy loss due to the friction of the different mechanical pieces of the forming section, rolls, ball-bearing, engine...
- Energy loss due to a sliding effect between the rolls and the fabric. If the sliding speed between the fabric and the roll is null then there is no energy loss. However, if the sliding speed is not null then, there is friction and so energy loss on the rolls.
- Energy loss due to the friction between the fabric and the dewatering elements.

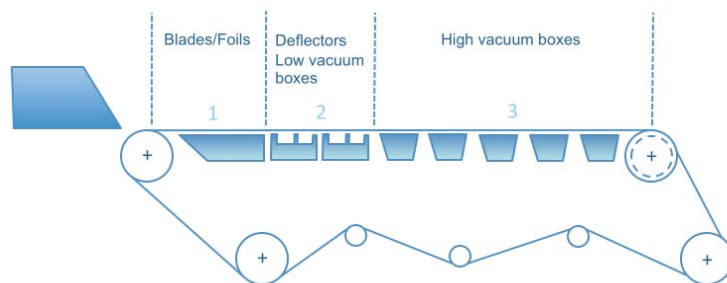


Figure 1. Dewatering elements on a Fourdrinier paper machine

Concerning the energy loss due to the friction between the fabric and the dewatering elements, it is said in general estimates that 15% is due to the friction with the foils/blades in the part 1 and 2 (on the scheme upper) and 80% is due on the high vacuum boxes, part 3. The remaining 5% are other losses (e.g. friction in the roll bearings, aso.). According to this statement, it was more interesting for us to focus on the high vacuum boxes than on another part of the machine. In this context a laboratory vacuum box was developed in order to predict the drag load and identify the main parameters.

Goals:

- be able to predict the energy consumption of a fabric on the paper machine
- identify the parameters that have an impact on the fabric drag load

3.2 Theory of friction on a vacuum box

On the vacuum boxes, the vacuum creates a force that pull down the fabric and slaps it on the ceramic parts.

Major parameters for the level of the friction force are:

- Coefficient of friction of the forming fabric material and the ceramic elements
- Normal force (R_{N1} & R_{N2}), Vacuum force
- Deflection and running side structure of the forming fabric
- Size of the contact surface, between forming fabric and drainage elements (Dynamic effect)

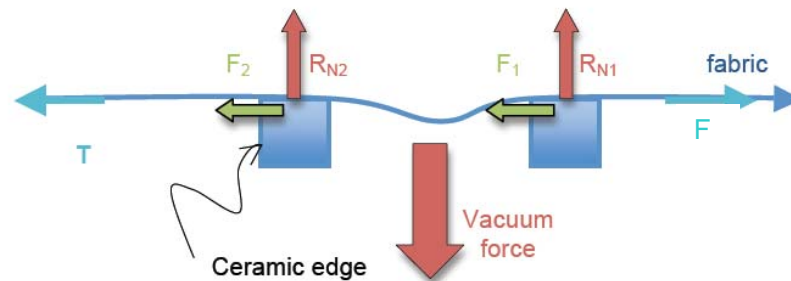


Figure 2. Theory of friction against a vacuum box

The friction force F of the fabric against a vacuum box is composed of two forces [Figure 2]:

- The friction force that is due to the increased normal force by the vacuum multiplied by the coefficient of friction.
- The friction force that is due to the small deflection of the fabric at the edge of each ceramic blade, mainly over the vacuum slot, that leads to a certain amount of form lock effect.

To create less friction of forming fabric over vacuum box the friction forces $F1$ and $F2$ have to be minimised. This can happen due to special running side structures and/or polymer materials or with controlled sheet forming in the initial part leading to easier dewatering.

4. Laboratory Testing

4.1 Description of the Testing Machine (figure 3)

Firstly, a paper sheet is formed on the fabric resulting in a consistency of approx. 10 to 12%. Then, the fabric is dragged over a small vacuum box with the extensometer at a constant speed of 0,5 m/min. Hereby water lubrication between the ceramic and the fabric is granted while excluding any hydrodynamic effects, that could influence the measurement result. The extensometer has a force sensor and measures the dragging force. A pressure sensor in the vacuum slot measures the real pressure under the fabric. A weight simulates the tension of the fabric on the paper machine.

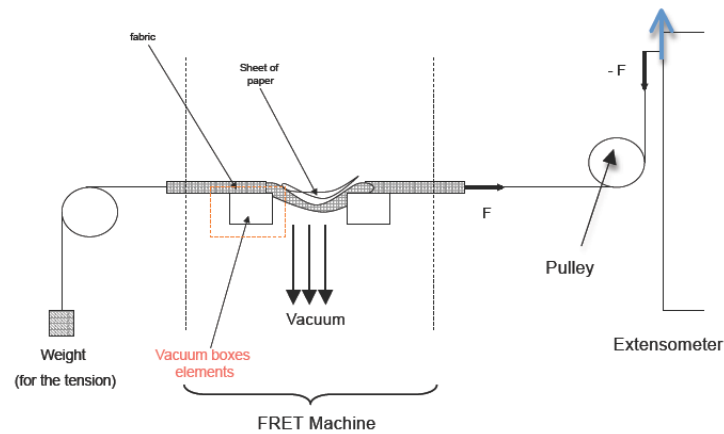


Figure 3: Scheme of the drag load machine

The Extensometer is pulling the fabric over the vacuum slot and is measuring the force needed. So it was possible to identify and verify the different drives of friction in the wet end.

4.2 Measuring of drag load

Initial measurements showed that the relation between the vacuum pressure and the drag force is linear [Figure 4]. This confirms that we focus on pure friction between the fabric and the ceramic element, avoiding any influence of dynamic effects.

In the following measurements the influence of running side surface topography and the ceramics were evaluated. Figure 4 shows a clear impact of the ceramic edge shape on the drag load, in the way that a sharp edge gives significantly higher drag load due to form lock effects, that add on top of the pure friction forces. This is evident as soon as the ceramic edge shape in combination with the forming fabric running side structure allows form lock effects to emerge.

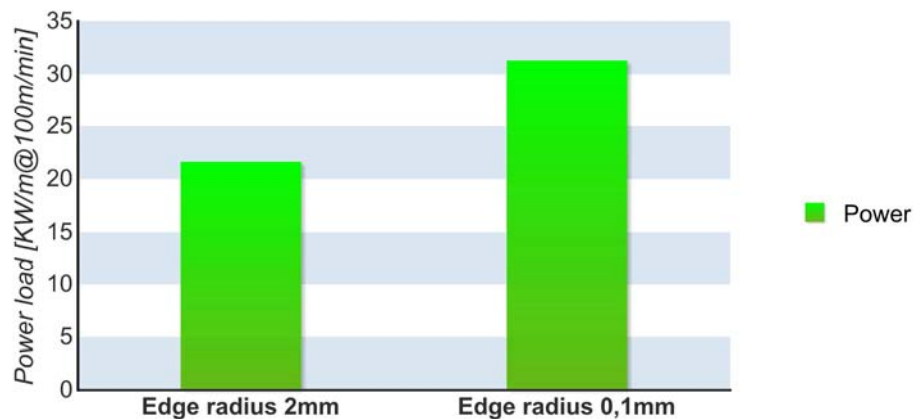


Figure 4: Influence of ceramic edge shape on drag load

In order to set the focus only on the friction between ceramic element and forming fabric, for the following evaluations a ceramic edge radius of 2mm was used.

We can conclude that both, paper and fabric parameters affect the drag load. Moisture of the paper sheet, the size of the fibres and basis weight are parameters that increase the drag load. Moreover, the fabric wear and polyamide yarns are fabric parameters that also increase the drag load. Finally, long float machine side and Low-friction yarns give very low drag load, this observation led to new fabric technology.

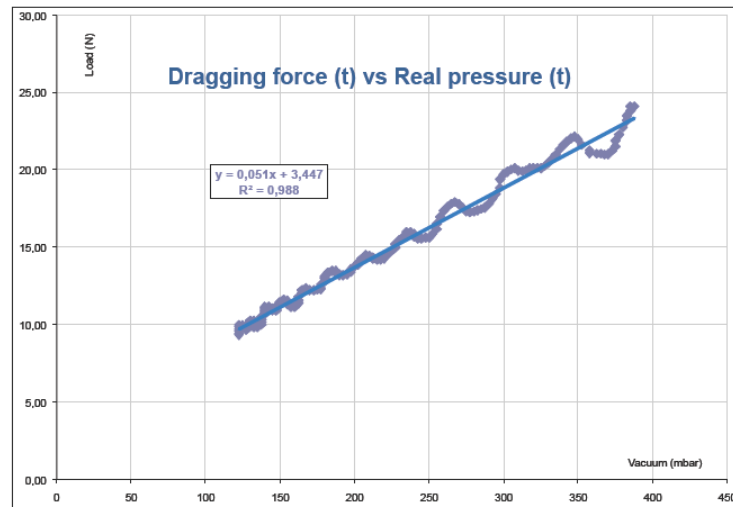


Figure 5: relation between the dragging force and the real pressure

4.3. Testing/Lab Results:

After over 50 Lab test a list of parameters influencing the friction force (drag load) could be established. Figure 6 shows the main parameters that are influencing the drag load. The value shows the drag load difference in [%] of the specific drag load (KW/m @ 100m/min) for each parameter versus the reference forming fabric, ceramic material and paper grade, e.g. low friction material gave 10% lower specific drag load in this experiment.

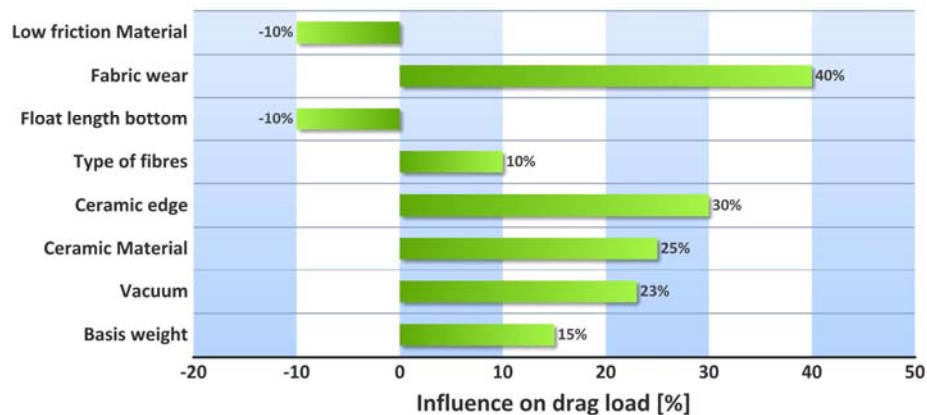


Figure 6: Main parameters influencing the drag load

Low friction Material:

It can be seen clearly that in Lab test the low-friction material has a positive impact on the drag load

Fabric wear:

The negative effect on the drag load is contradictory to the field experience, which shows a reduction of drag load over the fabric life. In the Lab the dynamic effect of a PM is missing therefore we exclude this parameter.

Float Length:

The float length of the weft yarn on the running side of the forming fabric is the part of the yarn sticking out of the fabric structure that is being abraded during the progress of the fabric wear. The longer the float the lower the drag.

Type of fibres:

The type of fibres cannot be influenced by the forming fabric, it is determined by the production program of the related paper machine

Ceramic edge:

The sharper the edge gets the higher the load. No forming fabric impact on the ceramic.

Ceramic material:

Different ceramic materials were tested with a result of different friction coefficient.

Vacuum:

Vacuum is mainly influenced by sheet forming process and the PM setup.

Basis weight:

The basis weight cannot be influenced by the forming fabric, it is determined by the production program of the related paper machine

Out of those 8 most important parameters we like to focus on 2 major friction drivers, which can be influenced by the forming fabric:

- Vacuum levels
- Friction coefficient of the forming fabric running side material

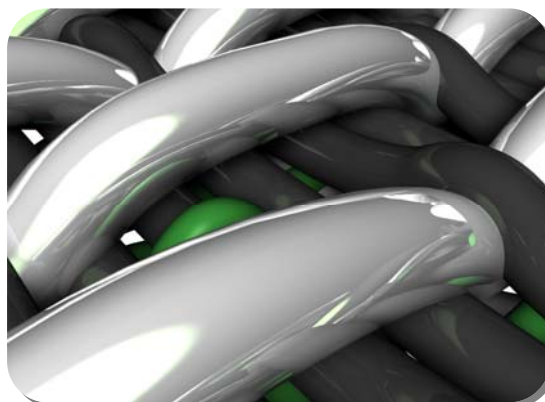
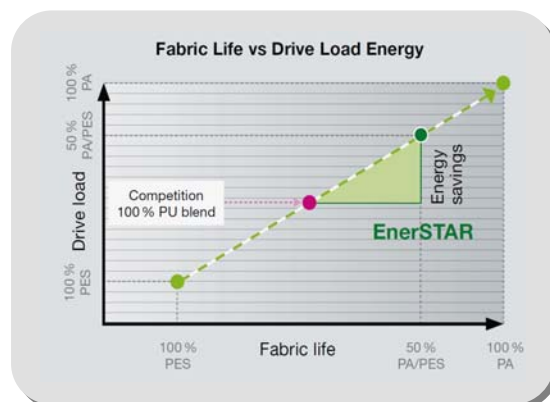
5. Impact of the forming fabric**5.1. Vacuum levels**

The vacuum level is the most important parameter. The higher the vacuum, that is applied on a box, the higher is its impact on the drive load. The vacuum level is depending to a large extent on the sheet formation process, is the sheet structure open enough after the initial sheet building it is easy to dewater, leading to lower vacuum levels and therefore energy savings in drive energy.

Field results showed the initial fibre matt should be open and not too dense. A too dense initial sheet seals the paper and reduces the overall drainage. The flow speed on paper side of the wire has a significant impact on the porosity of the initial fibre matt. A higher surface open area provides a lower flow speed and keeps the initial matt more open. In order to provide a more controlled drainage the surface open area on running side needs to be reduced. It is diametrically the opposite of conventional wisdom in the industry!

5.2. Forming fabric running side material

There are already materials available on the market with the same target of reducing drive load energy.



The only material available till now did reduce the friction coefficient of the fabric, but also led to a reduction of life potential. Secondly the existing material is limited in the available diameter range, which leads to a limited application scope, when it comes to paper grades and PM Types.

A joint development together with a yarn manufacturer resulted in a unique new running side material which combines the remarkable low friction to the dewatering elements with very high abrasion resistance. Thus the drive load can be reduced without any compromise regarding fabric life or stability. The new material technology can be introduced to a wide range of forming fabric applications, as there is no general limitation in terms of yarn diameters.

Summarizing, the new polymer material offers:

- reduced drag load => less energy consumption
- increased abrasion resistance => longer lifetime
- increased fabric stability

6. Field results:

Both, the Engineered Drainage Channels and the new running side polymer material have been introduced to market recently, in order to improve papermaking in terms of machine runnability, efficiency and paper quality.

Field results of either of the two mentioned technologies prove the expected benefits. The combination of both technologies, Engineered Drainage Channels together with the new running side polymer material add their sole benefits up to a even larger potential.

The benefits obtained in the field trials refer mainly to:

- lower drag loads due to less friction of the forming fabric on the dewatering elements
- lower drag loads due to lower vacuum levels
- lower vacuum levels due to easier water removal from the improved sheet structure
- higher sheet solids on pick-up
- improved runability
- possibility to run lower headbox consistencies resulting in improved paper formation at higher or constant retention.

The value of the mentioned benefits depends on the specific situation at the related paper mill. Based on the gained field experience it is very obvious, that these technologies offer great opportunities for cost savings in the paper manufacturing process.