Correct felt permeability: how open do press felts need to be?

Introduction

In order to remove water from the sheet in the press section, water must flow easily into the press felt. On the other hand, at the exit of the press nip, water must be kept from flowing back into the sheet. These conflicting demands ensure that felt permeability is always a compromise between good dewatering and re-wetting.

This article gives some background information on felt permeability and describes hands-on tools to determine and optimize the permeability of felts which are running in the machine.

The CFM value on the datasheet

As part of the manufacturer's quality control, the air permeability of every felt is tested and usually recorded on the datasheet. Although air permeability is an important parameter for the felt manufacturer, it is of limited value for the paper manufacturer.

Air permeability, in CFM or l/dm2.min, is determined by applying a very small pressure difference (of about 0.018-0.029 PSI or 1.27-2 mbar) between the two sides of a fabric and then measuring how much air flows through the fabric. In the case of a very fine, dense fabric less air will pass through and thus it will have a lower CFM value. This procedure works well for plain fabrics, such as forming fabrics and dryer screens.

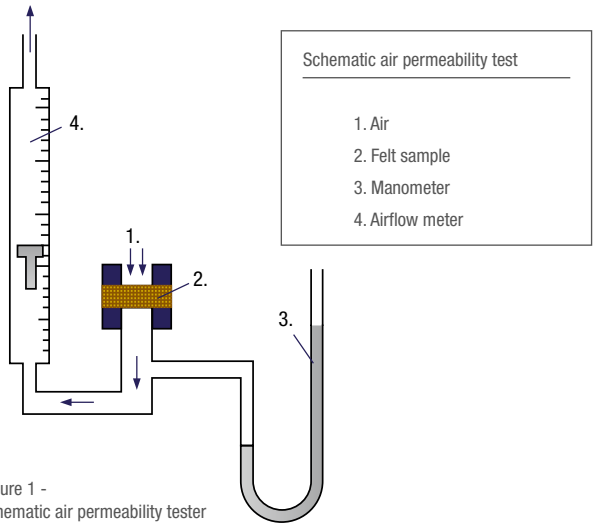

Figure 1 -
schematic air permeability tester

However, press felts are not plain woven fabrics, as they have multiple layers of very fine batt needled onto the base fabric. The needled batt is much denser than the base fabric and therefore only the batt determines the quantity of airflow and hence the outcome of a perm test.

In addition, the batt is usually made of polyamide which absorbs some water. This means that the tested CFM value may vary with local air humidity during the test – the higher the humidity, the thicker the batt fibers become, the lower the air permeability becomes.

One possible conclusion is that this test is hardly representative for the situation in which felts are used: large amounts of water, not air, passing through a compressed felt under high pressure. It is safe to say that the CFM value of a press felt is of no value for the papermaker.

Press concepts and permeability

When it comes to removing water from the sheet in the press section, there are two basic concepts: nip dewatering and Uhle box dewatering. The two concepts have slightly different properties when it comes to felt permeability.

Uhle dewatering

In the case of Uhle dewatering, the felt acts as temporary storage for water. It absorbs water in the nip and releases it in the Uhle box. This means there are some conflicting demands in respect of the felt permeability:

1. In the mid-nip the paper side of the felt must be open, so that water can freely move from the web into the felt.
2. To avoid re-wetting of the web at the nip exit, the paper side of the felt must be as dense as possible.
3. At the Uhle box, the felt must be open again, so that it can dispose of the water it contains within a relatively short time.

Illustration 2 - Uhle box dewatering

Nip dewatering

For effective nip dewatering, the felt needs to carry water into the press nip. Since the sheet also carries water into the nip, the hydraulic pressure in the nip will rise and at a certain moment water will move in the direction of least resistance.

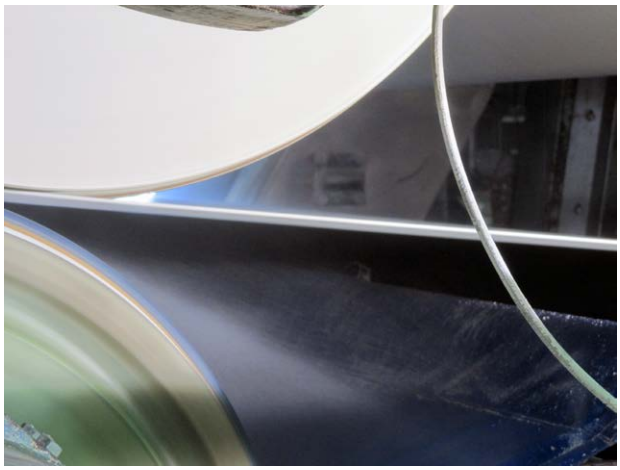

Illustration 3 - nip dewatering

From a felt permeability point-of-view, nip dewatering is a little easier than Uhle dewatering:

1. At the nip entrance, the felt must help to build up hydraulic pressure, so must be relatively dense.
2. In the mid-nip the water should be able to flow through the felt. To avoid the fines and fillers being washed out, the flow speed must not be too high: the felt may be a little dense.
3. Again, to avoid re-wetting of the web at the nip exit, the paper side of the felt must be as dense as possible.

Other runnability problems

When felts have become too open or too dense, the machine has its own way of letting you know: poor runnability. The table below lists some common phenomena, together with their relation to felt permeability.

Phenomenon:	The felt is:	Possible explanation:
Low dry content	Open	For example re-wetting at the nip exit, or…
	Dense	The felt cannot release enough water at the Uhle box.
Sheet crushing	Dense	Felt is too dense and the water damages the sheet.
Diagonally ripped felts	Dense	Water for the nip destroys the felt when it suddenly enters the nip.
Poor pick-up	Dense	The vacuum of the pick-up roll is not effective.
Shadow marking	Open	The mid-nip flow is too high, washing out fines and fillers.
Blowing for the 4th press	Dense	The vacuum of the transfer roll is not effective.

Table 1 – perm-related runnability problems

The 'right' felt permeability

It may come as no surprise that there is no general rule for correct felt permeability. From the above it may be surmised that machines running with nip dewatering require somewhat denser felts than those with Uhle dewatering, but that is about the only rule of thumb which applies. Optimal permeability depends on local circumstances, such as press and roll cover design, speed, stock quality, contamination etc., but also on the requirements of the paper manufacturer, such as break-in time, paper smoothness, minimum felt life etc.
As is very often the case, it is a matter of investigating what works best in a particular situation. Measuring felt permeability at regular intervals, such as every day at 9 AM, gives objective data for all machine conditions. The accumulated data gives the papermakers a point of reference, supporting them as they choose the most appropriate action to take.

Measuring felt permeability

To avoid the negative effects of incorrect felt permeability on the machine's runnability, it is important to judge the condition of the press felts on a regular basis. Felt manufacturers often use instruments such as L&W Feltperm™ or Cristini PermFlow™. These instruments inject pressurized water into the felt and then measure the water flow.
As these instruments are relatively expensive and not often used by the pulp & paper mills, they remain beyond the scope of this white paper.

Airflow through the felt

An easy and affordable way to get an indication of permeability is to measure how much air the Uhle box draws through the felt. Using an instrument such as the Feltest AirSpeed/2 this airflow can be measured accurately.

Illustration 4 - measuring airflow at the Uhlebox

Of course the measured airflow is closely related to the applied vacuum. Therefore it is good practice to also record the vacuum in the Uhle box when measuring the airflow. The Feltest RealVac is a handy portable manometer for measuring directly inside the Uhle box, rather than having to use defective manometers on the paper machine.

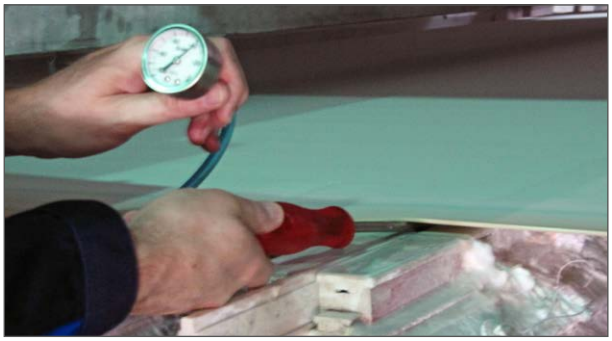

Illustration 5 - measuring vacuum inside the Uhlebox

Dynamic permeability indicator

In order to easily compare multiple measurements over time, it is best to have a single indicator which takes into account both airflow and the applied vacuum. When airflow is divided by the applied vacuum the result is such a 'Dynamic Permeability Indicator'.
The example in the table below shows that, although the measured airflow remains constant, the felt becomes denser as the vacuum increases.

Airflow	Vacuum	Dynamic Permeability
4.0 m/s	20 kPa	2.0 m/s @ 10 kPa
4.0 m/s	30 kPa	1.3 m/s @ 10 kPa
4.0 m/s	35 kPa	1.1 m/s @ 10 kPa

Table 2 - Dynamic Permeability (example)

Compaction or contamination?

After the installation of a felt, (dynamic) permeability starts to fall; the felt is compacting. However contamination will also make it denser. To distinguish between these two possible causes for a denser felt, the felt caliper must be taken into account.

In order to measure the felt caliper, the same applies as in the case of measuring the airflow: only doing so on a regular/daily basis will provide a point of reference in order to assess today's test result as 'relatively thick' or 'relatively thin.' The combination of the three tests (vacuum, airflow and caliper) provides very valuable information on the felt's overall condition, as can be seen in the table below.

Dyn. Perm.	Felt caliper	Cause	Other symptoms
Lower	Thicker	The felt is contaminated.	Sheet crushing, reduced speed.
Lower	Thinner	The felt is (too) compacted.	Sheet crushing, water for the nip.
Higher	Thicker	The felt is in its break-in period.	Poor dry content.
Higher	Thinner	The felt is worn.	Poor dry content, felt marking.

Table 3 - Relation between felt caliper and permeability

Adjustments to running felts

There are only limited ways of adjusting unfavorable felt permeability. If a felt is dense and not too compacted, thorough felt washing makes sense. On the other hand, when the felt is compacted, installing a new felt may prove more (cost) effective.
For open felts, the options are also limited. When felts are open because they are worn, they need to be replaced as soon as possible. When a felt is too open and still bulky, it is probably still in its break-in period. This situation can be improved by trying to compact the felt, for example by increasing the press load or introducing more water into the nip (by switching off one Uhle box).

Conclusions

Permeability is always a compromise between dewatering and re-wetting. The CFM value on the felt's datasheet is of no value to the paper manufacturer. Typically felts for nip dewatering are somewhat denser than for Uhle dewatering, but that is about the only rule-of-thumb for felt permeability.
It is important that the paper manufacturer know the usual felt permeability, so that they can detect deviations and react in time. Combining the test results from airflow measurement, vacuum and felt caliper gives an excellent indication of the felt's condition.

Written by Mr Marcel Lensvelt, Managing Director of Feltest Equipment BV.

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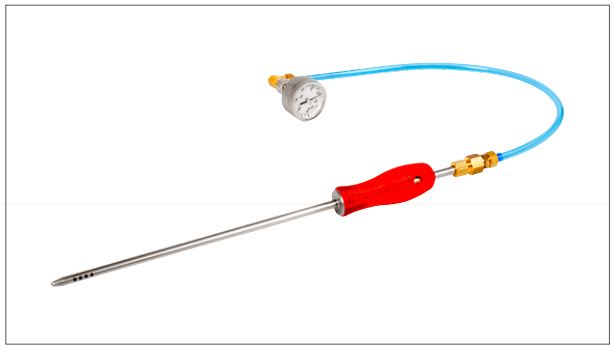

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