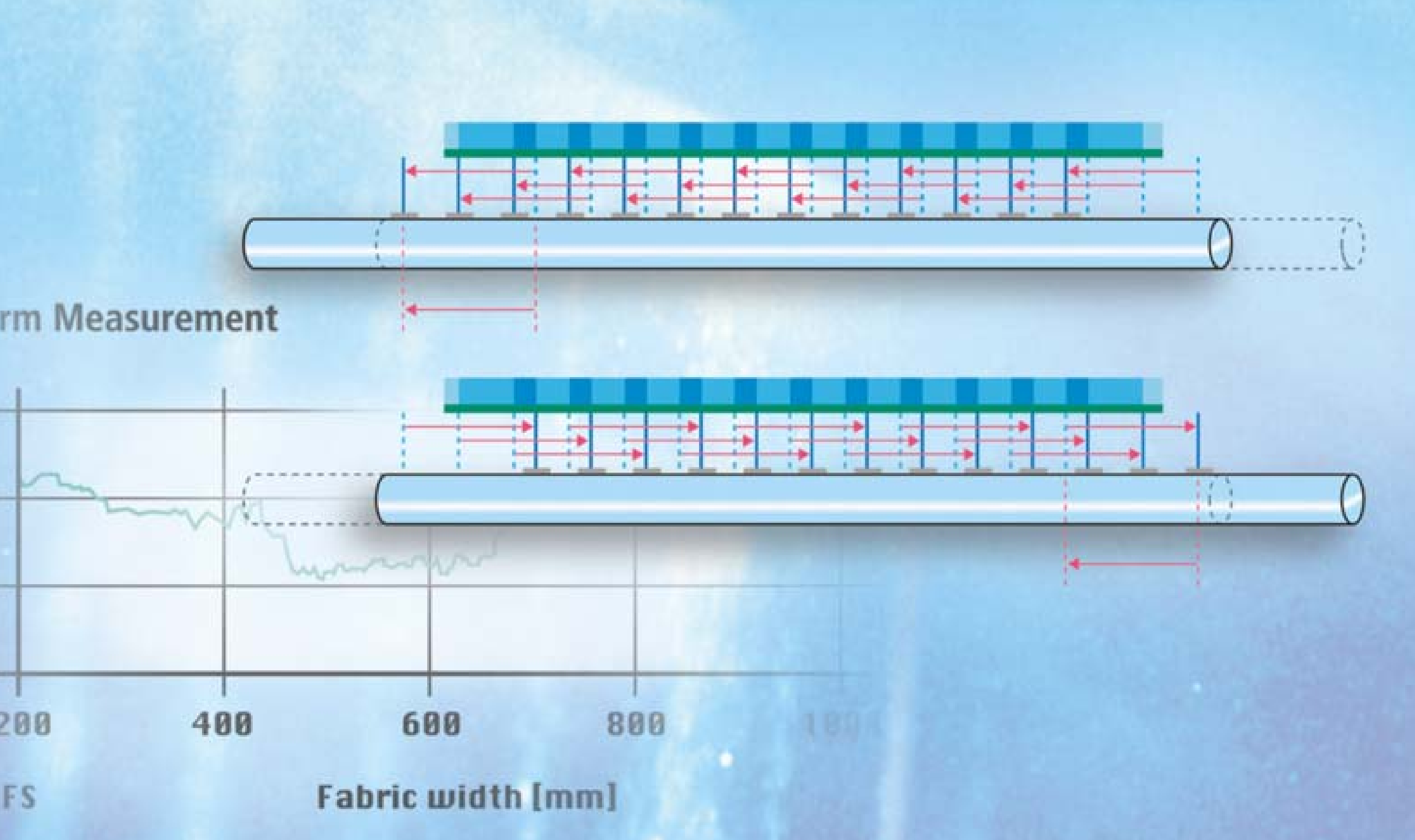

Forming Section | All Paper Grades

Press Release

Continuous conditioning of forming fabrics with high pressure showers

General observations on the technical process – and a case study of a problem – and its solution

Chris Kershaw, Vice President Corporate Marketing, Heimbach UK Ltd., chris.kershaw@heimbach.com
Hans J. Struck, PMS GmbH, Offenburg, pms-struck@rubynozzle.com

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GROUP

Continuous conditioning of forming fabrics with high pressure showers

General observations on the technical process –
And a case study of a problem – and its solution

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Introduction

In their technical diversity and with the high complexity of the technologies involved in their running, paper machines are really like "sensitive giants".

Perfect functioning of each single component is a pre-requisite and adds up to the performance of the paper machine as a whole. This will lead to the best paper quality, high production output, optimal runnability, maximum efficiency, and last but not least to a high degree of user friendliness and health and safety for the work force.

In the following we would like to show in detail the process and impact of conditioning forming fabrics with high-pressure shower systems.
By understanding and taking this into consideration, faults and even damage or financial loss can be identified and rectified as early as possible in the forming section.
Conversely, poor conditioning of forming fabrics may only become apparent much further down the line of the paper production, sometimes as late as on the reel.

In a case study we are going to prove how far reaching the effects can be of malfunctions that, at their point of impact, may be mistaken as only a marginal issue.

The study will show how laboratory analysis of fabric damage can be used to pinpoint faults and to diagnose possible causes. The relatively minor corrections required to deal with the problem show the high correlation between cause and effect.

Individual paper machine production parameters will of course influence the high-pressure shower system. Therefore we will focus in this article on how to avoid general situations known to have caused major problems on-machine.

1. General conditions for the functioning of high-pressure shower systems.

The purpose of high-pressure shower systems in the forming section is to remove contamination from the surfaces and within the weave of the forming fabric while it is running on a continuous basis. In order to achieve this, use is made of the kinetic energy of the water jets from the high-pressure shower nozzles.
In order to function efficiently, the shower system needs to be of a solid construction and to be installed at an appropriate position in the forming section and at the correct angle to the fabric. The shower should have an appropriate number of nozzles spaced at distances from each other that relate to the width of the oscillation stroke.
Effective mist removal should also be considered otherwise foreign matter that has been flushed out of the fabric could be carried back into the fabric weave by the shower mist.

1.1 Influence of fabric design on the function of conditioning systems

When choosing the correct angle of the shower jets and the appropriate water pressure, the structures of different fabric designs need to be taken into consideration.

- Single Layers have relatively large openings. The water jets can penetrate the fabric weave directly. (Fig.1).

- Double Layers have typically small openings (high count of yarns in machine direction). Therefore the path of the water through the weave is hindered and significantly slowed down (Fig.2).

- Triple Layers with integrated support structures (SSB-fabrics), are available in a variety of mesh sizes and internal structures and generally can be penetrated by water jets in a relatively unhindered way (Fig.3).

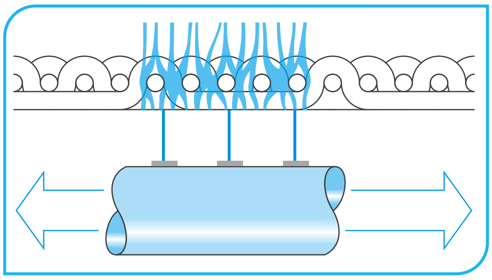

Fig.1 Water jets onto a single layer fabric, such as PRIMOFLEX from Heimbach

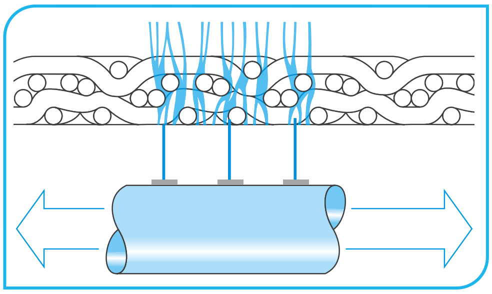

Fig.2 Water jets onto a double layer fabric, such as PRIMOPLAN from Heimbach

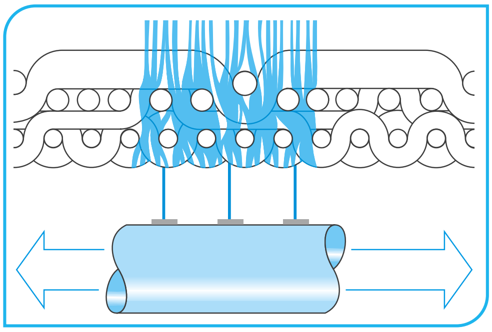

Fig.3 Water jets onto a triple layer SSB fabric, such as PRIMOBOND from Heimbach

The paper side construction of many modern fabric designs is extremely fine, in that diameters of machine and cross direction yarns are often as low as 0.11 mm. This makes the paper side surface of these fabrics quite sensitive to showering.

In contrast the machine side of many modern fabric designs is relatively robust, with cross direction yarn diameters ranging from 0.18 to 0.45 mm.

1.2 Properties of Water Jets

Each water jet must be presented to the fabric surface in a highly laminar way for the purpose of efficient coverage and cleaning of the fabric. The ideal needle jet should be fine, with well defined lateral boundaries, no air pockets, a constant diameter (Fig.4) and should meet the fabric surface with sufficient pressure. A **turbulent** jet, i.e. one that disintegrates into single droplets **before** impinging the surface (Fig.5), is much less efficient at cleaning the fabric and could – depending on the amount of water pressure – damage the fabrics.

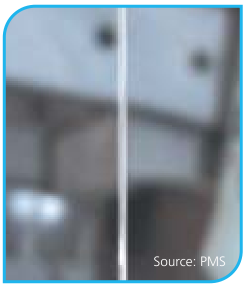

Fig.4 Laminar water jet Fig.5 Turbulent water jet

The properties of the water jet depend on the quality and precision of the nozzles and on constant water pressure. The latter should be at least 20 bar in the case of standard nozzle diameters (0.8 to 1.0 mm), but not exceed 35 bar. Good water quality will help with fault free functioning of the nozzles by preventing clogging of the nozzles or deposit build up and thus maintaining good jet quality.

Therefore nozzles with standard jet diameters between 0.8 to 1.0 mm need to be equipped with an efficient water filtration screen (usually before the high pressure pump) of 50 μm (300 mesh). Another point to take into consideration is the impact of the water temperature.

This should always be in the range of the production temperature, in order to avoid an uneven temperature profile with its resultant negative effect on cross direction profiles in the sheet.

Poor quality water jets also carry the risk of damaging the fabric: turbulent jets can cause the machine and cross machine direction strands to vibrate quite intensely (Fig.6) causing the strands to wear at the cross-over points and leading to fibrillation. This can reduce the permeability and machine direction stability in localised areas of the fabric.

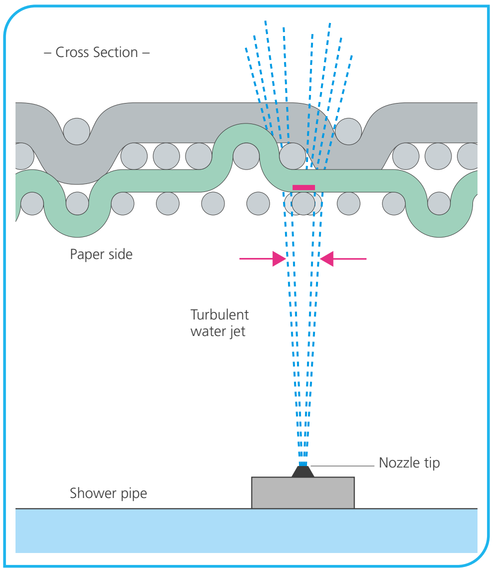

Fig.6 Potential fabric damage

Modern Ruby nozzles, with their high jet quality and long life performance, will usually eliminate most of the problems described above. A regular check-up of the water jets is recommended in order to identify and rectify any problems at an early stage. Defective, contaminated or partly blocked nozzles will lead to a change in the water jet properties (Fig.7), causing uneven coverage across the fabric width (Fig.8) and poor cross direction profiles in the sheet.

Fig.7 Various types of water jets

The use of a hand stroboscope is recommended to assess the water jet quality of the high-pressure

Fig.8 Uneven coverage

showers. The stroboscope is adjusted to approx. 50 to 60 Hz and is held flat above the shower pipe and directed towards the jets exiting from the nozzles. This will allow observations that would be impossible under normal lighting conditions.
At a fabric changeover a short trial run of the showers should be conducted. This should be done before the new fabric is installed otherwise it may not be possible to see all the water jets. In order to conduct the trial run during a machine shut it may be necessary to temporarily connect an alternative water supply to the shower pipe.

When assessing the cleaning performance of the jet (please see the table in Fig.9 for nozzle diameter and water pressure values), the elastic response of the fabric should be considered.
On the one hand this will counteract the jet impact but it will also cause a small movement of the fabric strands.

Jet diameter [mm]	Water pressure [bar] 20	25	30	35
0.6	0.73	0.81	0.91	0.96
0.7	0.99	1.10	1.23	1.30
0.8	1.26	1.41	1.59	1.68
0.9	1.59	1.80	2.03	2.15
1.0	2.00	2.30	2.58	2.73
1.1	2.48	2.85	3.18	3.39
1.2	3.00	3.45	3.90	4.14

Source: PMS

Fig.9 Volume flow in needle jet nozzles [l/min]

This movement will loosen contamination particles, which are mainly deposited around the cross-over points of the fabric strands, making them much easier to flush out.

Care should be taken to ensure that the water pressure does not exceed the above limits as this can lead to fabric damage with a loss in performance and lifetime.

As a general rule the pressure should be as high as necessary in order to achieve good cleaning results, and it should be kept as low as possible in order to avoid damage to the fabric (Fig.10), and in the interest of energy efficiency.

Fig.10 Fabric damage through excessive jet impact

1.3 Configuration of the high-pressure showers – Cleaning process and removal of contamination particles

High-pressure needle jet showers are often installed between two rolls on the return loop and are directed onto the paper side of the fabric (Fig.11).

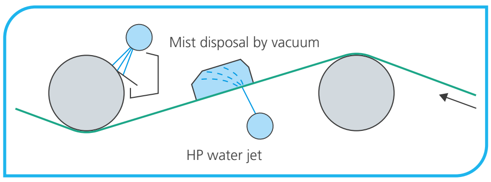

Fig.11 Usual layout: Water jet between the return rolls

The shower should be positioned as early as possible on the return run to avoid contaminants being pressed into the fabric by the return rolls. Typically the needle jets are positioned perpendicular to the fabric surface. The fabric will carry part of the water with it with the remainder penetrating the fabric and taking with it any loosened contamination particles.

This water is diffused by the fabric structure and movement and can create a water mist on the inside of the return loop (Fig.12).

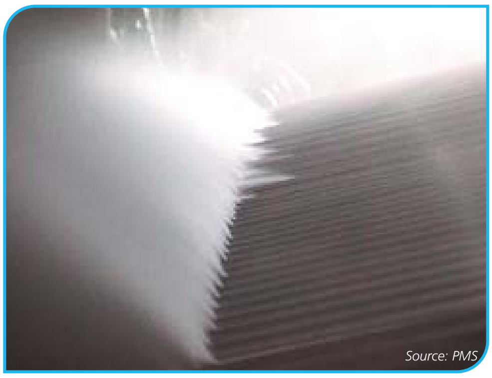

Fig.12 Water mist in the space inside the fabric return loop

The high concentration of contaminant material in this mist can cause problems with deposit build up in the forming section especially on high-speed machines. Suction boxes are often installed to take up and remove this water mist.

It is becoming increasingly common to direct the shower onto the fabric as it passes over a return roll (Fig.13).

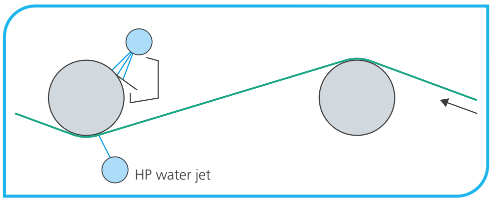

Fig.13 Variation: Water jet onto return roll

The water jet penetrates the fabric body and hits the roll surface, which causes a pressure pulse to pass back through the fabric. This mechanism loosens fibre, filler and other contaminants from the fabric and they are flushed out. (Fig.14).

Part of the flushed out contamination will deposit on the roll surface and so good doctoring is required. The doctor blade itself should be showered to keep it clean and lubricated. (Fig.14).

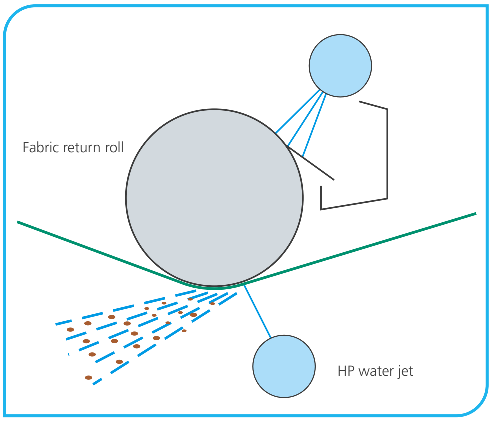

Fig.14 HD water jet onto fabric return roll

The advantage of this shower layout is that there is no misting on the inner return loop and therefore none of the associated deposit problems described previously.

It is also possible to run two high-pressure shower systems, one directed to the paperside and the other to the machineside surface of the fabric (Fig.15).

This is recommended especially when running SSB fabrics which, although they are very open designs, have a high caliper and therefore can be cleaned more efficiently through needle jet impingement from both sides. These systems are similarly available with integrated closed suction boxes to remove spray and mist.

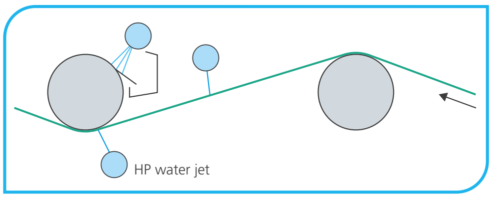

Fig.15 Variation: Inner and outer water jet

2. Positioning and Operation

It is recommended that high pressure showers should always be installed so that **the distance between nozzle and fabric surface is between 25 mm and 100 mm. The shorter the distance, the better the laminarity of the water jet.**

At a distance in excess of 100 mm the kinetic energy of the jets will start to lose intensity and the jets will start to lose laminarity and break up into droplets. These two effects will reduce cleaning performance. In addition, the action of the droplets impacting on the fabric can lead to severe shower damage.

2.1 Impact angle of the water jets
Deflection of the shower pipes

The jets should generally be positioned in such a way that the water jets impinge onto the fabric surface at an angle of 90° plus 10° in the run direction (Fig.16).

If the **angle of the water jets is much greater** than this it can result in reduced cleaning performance, due to a smaller difference between jet and fabric speeds.

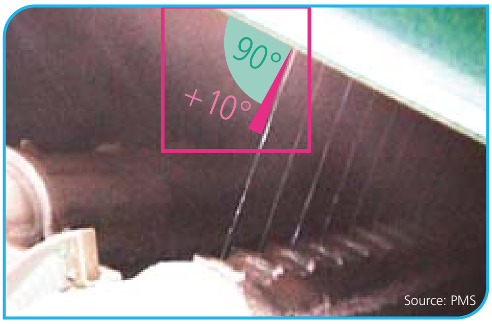

Fig.16 Ideal angle of the water jets

An **impingement angle that is against the run direction** can lead to a slow down in fabric speed, higher power consumption and increased fabric damage. It may be necessary to adjust the impact angle slightly in order to achieve optimum cleaning performance.

Deflection of the jets must not be allowed to occur under any circumstances, as this would lead to the levels of cleaning across the fabric width being inconsistent. To achieve this the jet nozzles need to be cleaned and maintained on a regular basis. Sagging shower pipes can be stabilised by having a triangular support welded onto them in a suitable position so as to attract a minimum of deposits. (Fig.17).

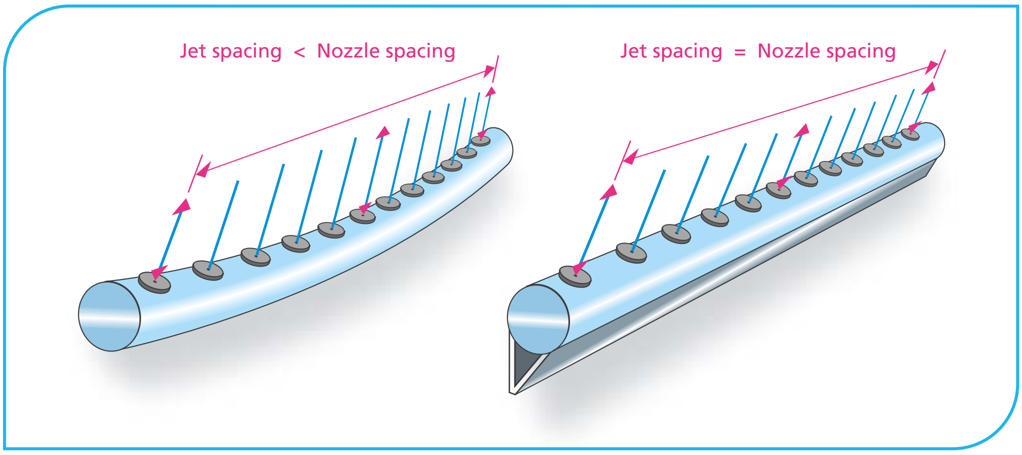

Fig.17 Even water jet spacing through pipe reinforcement

2.2 Separation distance between the nozzles Cleaning efficiency in the area of the fabric edges

One of the most important criteria for the correct functioning of a shower system is the oscillation stroke, and especially the ratio between oscillation stroke and nozzle spacing.

The usual distance between nozzles ranges from 50 to 100 mm. The total number of nozzles – and therefore the distance between them – depends on the level of cleaning performance required taking into account pulp quality, fabric speed etc.

Highest priority must be given to an evenly spread jet coverage over the **whole** fabric width. Therefore the distance from the first nozzle on the front side to the last nozzle on the back side of the fabric has to be as follows:

- Equal to the fabric width minus 1 nozzle spacing where the oscillation stroke equals 1 nozzle-spacing (Fig.18)
- Equal to the exact fabric width where the oscillation stroke equals 2 nozzle-spacings
- Equal to the fabric width plus 1 nozzle spacing where the oscillation stroke equals 3 nozzle-spacings
- Equal to the fabric width plus 2 nozzle spacings where the oscillation stroke equals 4 nozzle-spacings (Fig.19)

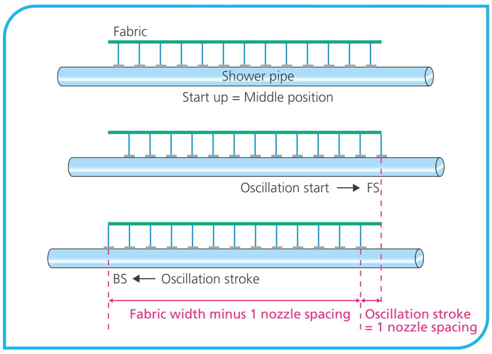

Fig.18 Distance between nozzle FS to nozzle BS: fabric width minus 1 nozzle spacing

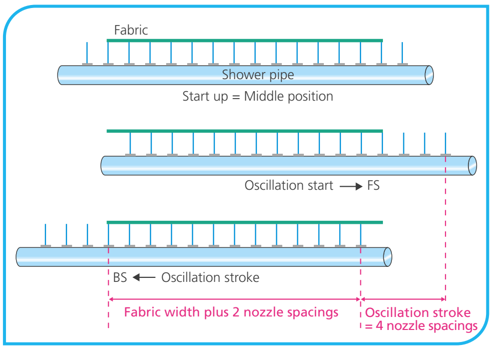

Fig.19 Distance between nozzle FS to nozzle BS: fabric width plus 2 nozzle spacings

Unless this is adhered to, there would be the risk of reduced coverage in the edge areas of the fabric.

3. Oscillation – and the correlation between the effect of high pressure showers and cross direction moisture profiles

A well maintained shower system makes a specific contribution towards finished paper quality because efficient cleaning of the fabric will help achieve balanced cross direction moisture profiles.

3.1 Oscillation Stroke

For the oscillation stroke to work with optimum efficiency it **has to equal the exact nozzle spacing or a multiple of it.** If this is not the case, streaks will occur across the width of the fabric as a result of over or under coverage. (Fig.20).

The schematic illustration shows an example of an incorrect oscillation stroke of 2.33 x the distance between nozzles. This leads to wet streaks across the width of the fabric and the sheet, caused by uneven overlapping of the showers, and dry streaks at each of the edges. It is a well-known fact that these streaks cannot be eliminated from the sheet either by the press or the dryer section.

3.2 Oscillation Speed

The key to achieving continuous coverage and providing comprehensive fabric cleaning action, is the oscillation speed. A jet of 1 mm width will provide coverage and fabric cleaning in strips of 1 mm width. In order to avoid gaps between the cleaned strips, it is crucial that the oscillation stroke per fabric cycle be the same as the diameter of one jet. In the above example, this would amount to 1 mm (Fig.21).

Let us expand the example and suppose the nozzle-spacing on the shower pipe is 100 mm. In order to cover the fabric in an endless spiral without any gaps, and most of all, in order to clean it efficiently, the fabric would have to go through 100 cycles. In the course of these 100 cycles each jet will clean a strip of fabric in a width equal to **one** nozzle spacing, i.e. 100 mm.

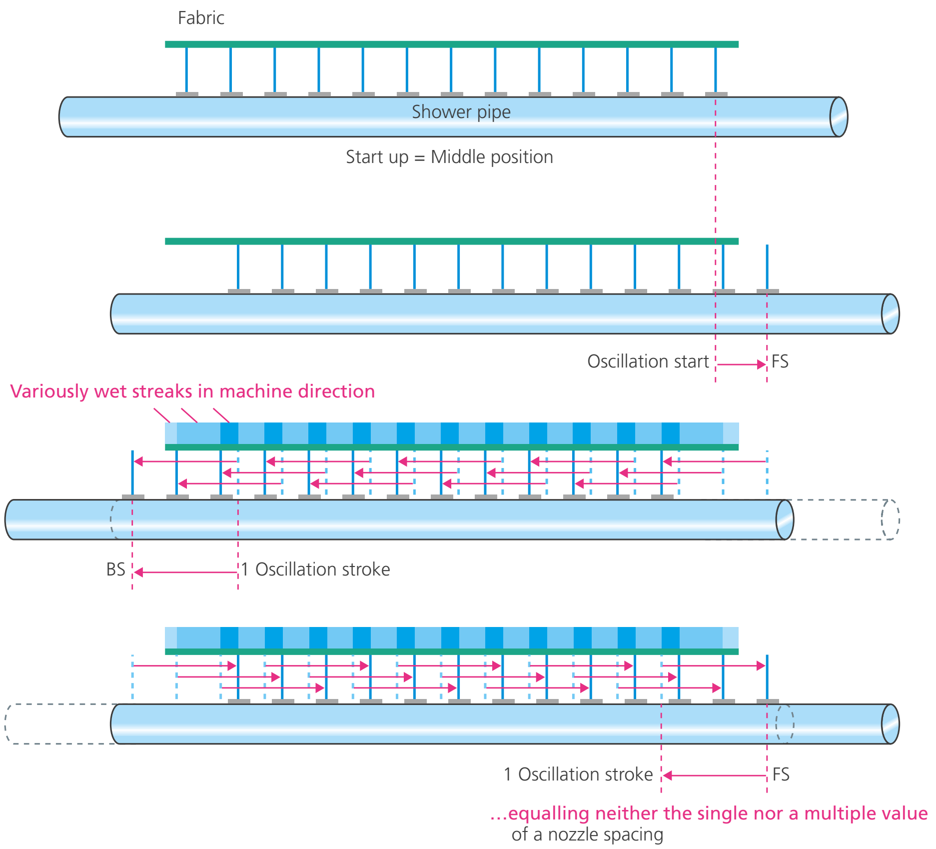

Fig.20 Example: Wrong oscillation stroke set up

Continuous conditioning of forming fabrics with high pressure showers

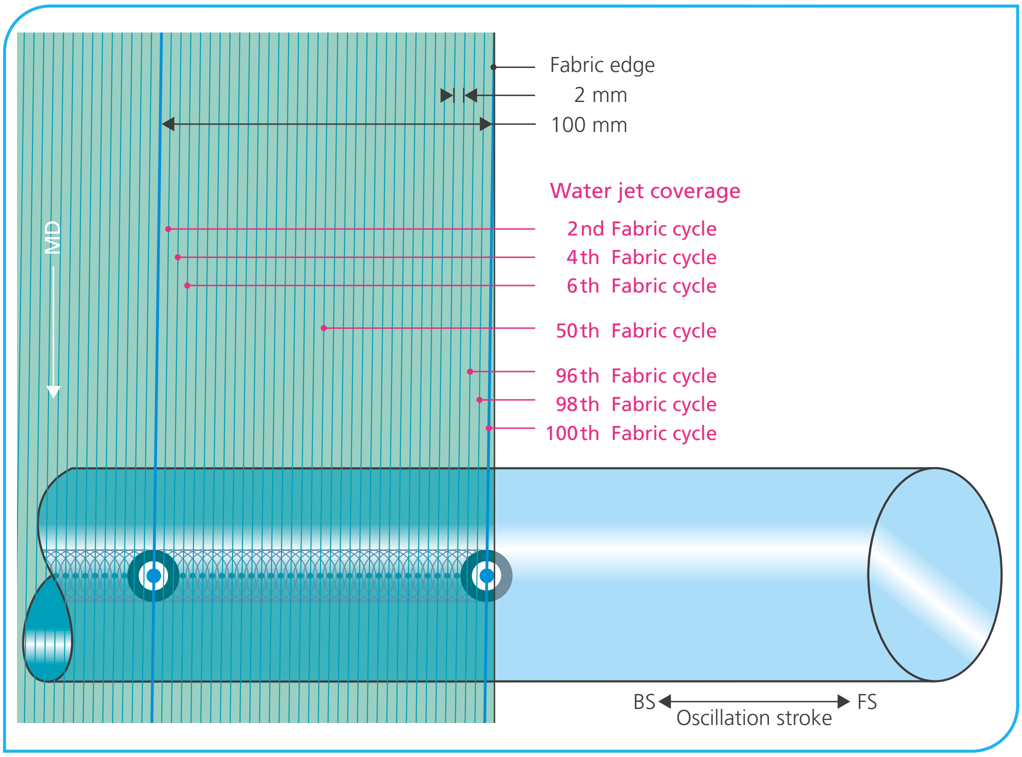

Fig.21 Oscillation speed

It is only through setting the oscillation speed exactly, following the principle of the above example, that continuous coverage and cleaning of the fabric, without any gaps can be achieved.

An oscillation stroke which is too fast, will lead to gaps between the cleaned strips (this has to be avoided at all costs); while an oscillation stroke which is too slow, will lead to overlaps (this could be tolerated to a certain degree).

Some paper machine operators set the oscillation speed at the lowest value and do not adjust it following minor increases in production speed.

Fabric length and fabric speed are the basis of calculating the correct oscillation speed in mm per second [mm/s]. The formula is as follows:

(Fabric Speed [m/min]
x single Jet Diameter [mm])
/ (Fabric Length [m] x 60)
= mm/s

…applied to our example:
(v = 1500 m/min **x** 1 mm)
/ (30 m x 60)
= 0.833 mm/s

In other words the longer the fabric, the slower the oscillation speed. And: the slower the machine speed, the slower the oscillation of the shower nozzles.

Two essential conditions have to be met, in order to achieve optimal oscillation:
Ideally the oscillation speed would be continually synchronised with the machine speed via the drive control, maintaining the calculated ratio of movements. Otherwise it would have to be adjusted manually whenever the machine speed changes.

It is essential that the oscillation drive transmission system does not allow any dwell time to occur at the return point of the oscillation stroke. Dwell times in excess of 0.02 seconds at the return point will be shown as regular zonal stripes in the fabric. This can cause yarn fibrillation and loss of fabric stability leading to sheet profile problems.

Oscillation stroke, oscillation speed and the transmission system should be checked at regular intervals.

Conclusion

As stated at the beginning: paper machines are "gentle giants". We hope to have demonstrated, that adjustments of as little as a single millimetre can often make the difference between optimum or poor functioning, which very often can have consequences all the way down the line and affect the quality of the paper on the reel.

The practical implication of this for continuous conditioning of forming fabrics with high pressure showers is that precise design, installation and adjustment of the equipment will not only save the inconveniences of malfunctioning, but can lead to substantial time and financial savings. The following **case study** will provide good evidence for this statement.

4. Case Study: A Problem – and its solution

Position: Inner Fabric / Duo Former

Problem: Cross direction profile peaks in the sheet with weight variations of up to 35 g/m^2 in an area of approx. 430-730 mm from the front side edge

The problem started approx. 9-12 days after start up and reaching full production speed. The situation deteriorated gradually over the remaining lifetime of the fabric. This lead to the fabric having to be taken out early, after only 3-4 weeks of production time. This was observed on a total of 6 consecutive forming fabrics of various designs, including 2 PRIMOBOND fabrics from Heimbach.

4.1 Identification of the cause and analysis by Heimbach TASK-Division specialists of how the problem developed

Results of first examinations and measurements taken:

No wear on paper or machine side of the fabric surfaces in the problem area as identified above. Fabric caliper measurement on machine (only up to 250 mm in from the fabric edge): nothing to report.

No creases or visible deformations of the fabric, however, light optical stripes seen in the problem area. Fabric tension was a constant 7,5 kN across the whole fabric width – i.e. normal.

First Lab Results of the Fabrics

When examined in the lab, the fabrics revealed the presence of internal abrasion in the problem area, which had been caused through extreme wear on both machine and cross machine direction yarns (Fig.22).

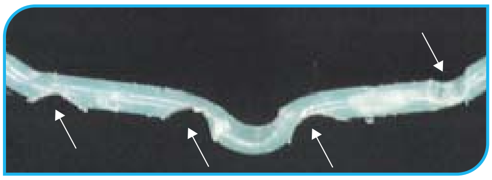

Fig.22 Machine direction yarn showing internal abrasion

It became apparent, that the problem area, situated between 430 and 730 mm inside of the FS edge, had been exposed to strong forces, causing the yarn abrasion and resulting in compression of the fabric structure (Fig.23).

No similar damage was found in any other areas across the remaining width of the fabrics. Fabric damage in the problem area, which could be regarded as a plausible cause for the cross direction profile peaks had been identified – but the reasons for the development of the profile peaks as well as the cause/s of the fabric damage remained to be identified.

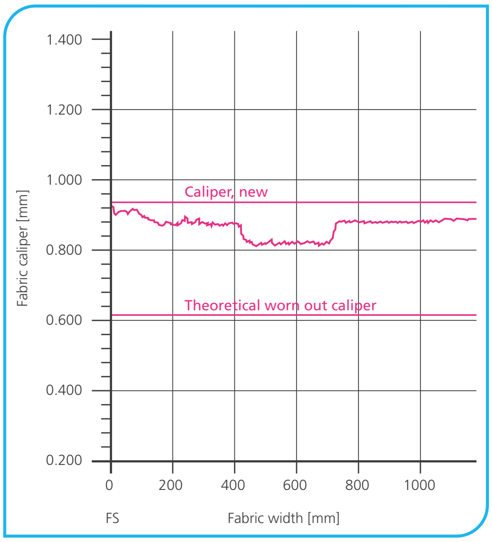

Fig.23 Caliper profile in the problem area

Further Measurements – Investigation of Causes

Water permeability measurements were made on one of the fabrics, after it had been taken out, (Fig.24). This showed a significant reduction in the water permeability at the exact position of the decreased caliper (compare to Fig.23).

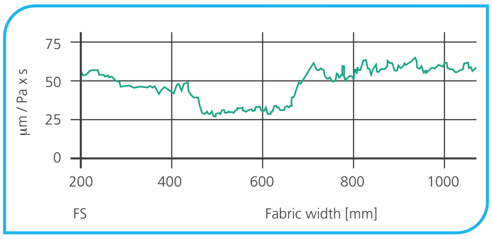

Fig.24 Wire-Perm Measurement (Resistance to flow)

In order to confirm these findings, a comparison with a PRIMOBOND fabric was made between the results of Wire-Perm-Measurements that were taken on machine during day 27 of the fabric's lifetime and a set of caliper measurements taken in the Heimbach lab after the fabric was removed 3 days later.

The form of the graphs was nearly identical and led to the same conclusion (Fig.25): the caliper had been significantly reduced through internal wear and compression, the dewatering channels had been compacted accordingly and the resis-tance to flow had been significantly increased.

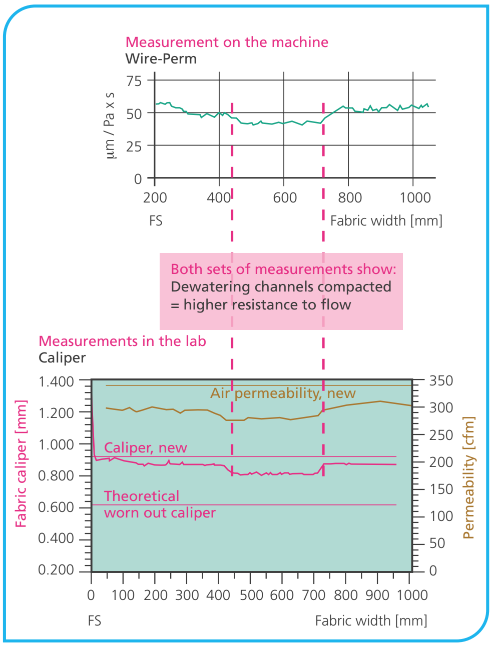

Fig.25 Comparison of on-machine vs lab measurement PRIMOBOND from Heimbach

Interestingly the air permeability profile of the problem area did not vary to the same extent, which could be regarded as significant. Subsequent measurements taken from other fabrics showed the same results.

This comparison had provided a direct cause for the development of the cross direction profile peaks. However, there was as yet no identification of the cause of the fabric damage.

4.2 Cause of the Fabric Damage

The cause could only be found from inside the machine, as it had to be a mechanical issue. After an intensive and very detailed inspection of all possible areas, conducted both with the machine stopped and running – the highly experienced Heimbach-specialists, with tremen-dous practical support from the customer, finally managed to get to the bottom of the problem. The cause of the fabric damage was of such a simple nature, that it initially seemed unbelievable:

One single nozzle of the high-pressure shower pipe in a position that was

difficult to reach and to inspect had been damaged in such a way that it was producing an extremely turbulent, pulsed water jet. The following photos illustrate this effect (Fig.26).

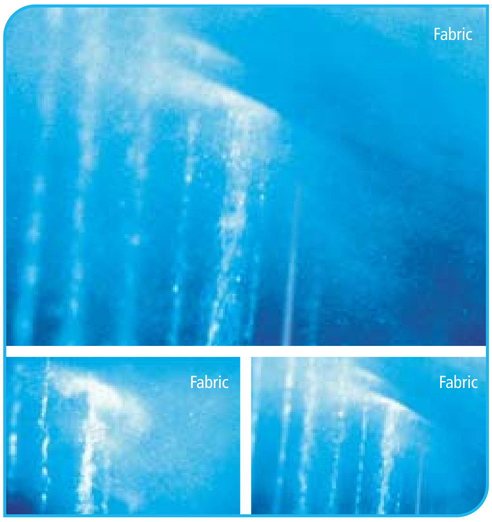

Fig.26 Water jet hammering against the fabric

As a result of this malfunctioning, the water jet had been battering the fabrics in a continuous hammering action. The fabrics had been literally "beaten into a pulp".

In addition to the fabric damage in the small strip of the problem area, hardly any fabric cleaning had taken place at all.

Consequently the dewatering channels were significantly reduced in their efficiency not only through being mechanically compacted, but by being highly contaminated as well. (By the way, only one of the other jets shown in the photo in Fig.26 is in a satisfactory condition.)

The damaged nozzle was replaced and the whole length of the shower pipe was overhauled. Fabric life times increased from 3-4 to 8-10 weeks. Significantly better fabric cleaning and improved cross direction moisture profiles were also achieved.

Summary

We would like to return to a statement made in the introduction to this article and complete it with the financial cost of the above problem.

The discrepancy between "cause and effect" in our case study has had truly disproportional effects:

The financial loss due to fabric costs, machine stops, loss of production, rejects, complaints by customers (printers) and extremely high additional loss of time added up to several hundred thousand Euro.

The new nozzle, its installation and the overhaul of the shower pipe amounted to an investment of approximately 500 Euro.

These two simple concluding sentences describe in a very clear way the totality of technological relevance in the paper making process.

The high-pressure shower system is but a minute part in all this.

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