Mechanical cleaning of paper machine clothing

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SUMMARY

A general comparison between different methods shows that high - pressure showering with water, water/air, or steam is far more effective than cleaning with an air shower. Cleaning with chemicals, which is necessary with difficult contaminations, is very effective in most cases.

However, it should be borne in mind that the choice of cleaning method should be based on the type of contamination, among other things. In many cases, even air showering ought to be a sufficiently effective method.

To obtain the best possible results with different cleaning methods, knowledge about contamination fabric design and cleaning technology is essential.

It is important to determine which contaminants in the fabric are most prevalent and which are the most serious. Table II shows some suitable cleaning methods for the most common forms of contamination.

Cleaning requirements increase particularly in those cases when large amounts of recycled paper are used. Pulp based on recycled paper lead to markedly increased contamination such as tar, asphalt, latex, waxes and plastics. Cellulose fibres, dust and other loose particles can be effectively removed from open dryer fabrics by continuous air showering. Large amounts of fibres and non-organic material, as well as chemically based contaminants, require a more effective cleaning such as high-pressure showering with water or steam. Low-pressure showering with hot water is a good method for removing large amounts of coating and sizing chemicals.

The function and life of paper machine clothing significantly influence the economy of the machine operation. The optimal choice of clothing does not only include machine and paper grade consideration but also easy cleanability and it has to be backed up by effective cleaning equipment in the machine. The demands have strengthened in recent years for different reasons, e.g.

— longer life of clothing
— increased use of recycled fibres
— higher degree of system closing
— trouble-free operation at higher speed

Contamination of a forming fabric could

— impair paper quality
— increase number of paper breaks
— make sheet release more difficult
— decrease life of the fabric

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Contamination of a press felt could

- impair paper quality
- cause lower press dryness
- give crushing
- cause sheet stability problems like edge drops and blowing
- cause sheet breaks
- decrease felt life

Contamination of a dryer sereen could

- impair paper quality
- cause instability of the sheet run especially at the edges
- cause uneven moisture profile
- give inferior heat transfer
- give contamination of paper sheet and cylinders
- cause shorter running life

This paper will mainly deal with high pressure showering of forming fabrics, press felt and dryer screens.

Experimental

The most important parameters in high pressure showering have been varied in a test equipment, Fig.-1 It consists of an oscillating high-pressure shower (HPS)

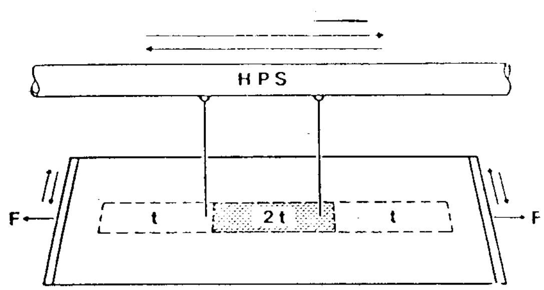


Fig. 1 Schematic figure of the experimental equipment
F fabric tension
t treating time
HPS high-pressure shower

with two exchangeable nozzles The shower was connected to a centrifugal pump with a capacity to produce water pressures up to 7 MPa. The tests were performed against a fabric or felt sample placed in a holder that was oscillated in the same plane but perpendicular to the direction of the shower. The distance between the sample and the nozzles could be varied between 20 and 600 mm. The oscillating frequency of the sample could ibe set between 0 and 40 Hz, and fabric tension between 1 and 15 kN/m. The distances between the nozzles (70mm.) and the oscillating length(120mm) of the shower were chosen so that overlapping was obtained in the middle part of the treated fabric area. In this way two test areas were obtained for each fabric sample. The total treated rectangular area was 190 mm long and 50 mm wide.

It is important to understand the character and function of the water jet. For a needle nozzle the jet leaving the nozzle is homogenous in the beginning and with mainly a laminar flow. After about 100-150 mm it starts to form into small drops with high energy Fig 2). Its diameter has also increased to 2—3 time that of the nozzle. The distance to the interval where the jet disintegrates depends on water pressure, the design of the nozzle, and water temperature. A higher pressure will mean a shorter distance. With the jet changing in character from a homogenous flow to a particle ,one, its ability to open and clean a fabric or a felt also changes, A jet is at its best when consisting of particle flow.

A fan nozzle is designed so that the jet is spread already in the orifice. A large percentage of the energy of the jet is thus lost to the nozzle and in general the jet never reaches the high effect of a needle nozzle. This is very evident from the results reported here.

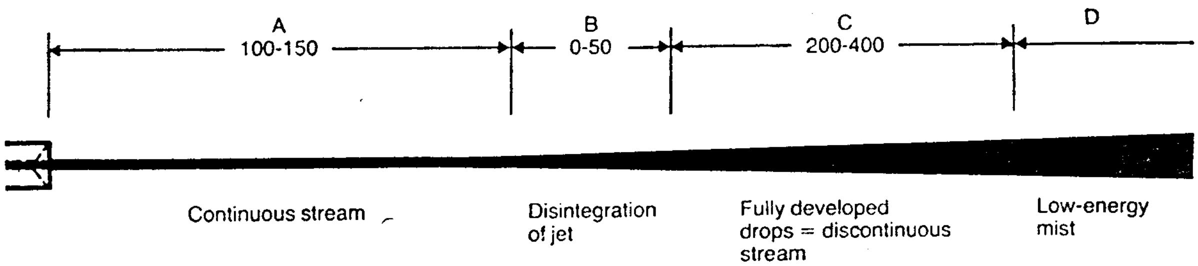
FORMING FABRICS

Both single-layer and double-layer forming fabrics were tested. In order to simulate contamination of the fabrics, they were impregnated with an acrylic resin mixed with caolin and a dyestuff. A major part of the resin was then deposited on the paper side of the fabrics. A great number of contaminated fabrics that had been run in commercial paper machines were also tested. The evaluations of the damaging effects were in most cases carried out with clean and new fabrics. Indeed, returned fabrics from paper machines were used to test the influence of wear on the damaging effect.

Evaluation methods

The cleaning effect was evaluated by visual exami-

Fig. 2 Schematic figure of a high-pressure needle shower. Distances in mm.



nation and by air permeability measurements. As the visual examination correlated well with the air permeability measurements only the air permeability values are given here. These measurements were made at a pressure drop of 100 Pa with a portabel air permeability tester.

In the case of forming fabrics the damaging effects were evaluated by measuring the time to the moment when the first 5-8 fibrillated or split monofilaments could be noticed. The time abtained with the test equipment with its comparably small treated area was then converted into days per square meter of fabric. In this way, it is possible to compare this laboratory time to damage (t_e) with the treating time to damage in a specific paper machine (t_m) :

t_m = L x d x t_e where
t_m = time to damage in paper machine, days
L = fabric length, m
d = distance between the nozzles, m
t_e = obtained time to damage, days, in the laboratory tests based on one nozzle and one square meter.

An estimation of risk of damage could thus be made from such a calculation.

Shower location

The location of the shower, i.e. outside or inside the fabric, is of very great importance. Earlier the shower was often located on the inside. The idea of this arrangement was probably that contamination should be removed the same way as it arrived. However, tests on both synthetically contaminated fabrics and on used fabrics from paper machines showed that a considerably higher cleaning effect is obtained when the water jets hit the paper side of the fabric, i.e. with shower outside the fabric In general the main part of the contaminants on a fabric is situated on the paper side. On the back side, the contamination is worn away. By using the shower from the outside, a greater part of the jet energy is assimilated by the contamination than by using form the inside. A change of the shower from inside to outside the fabric should be the first step towards making the cleaning more effective. This has recently also been confirmed in practice on a great number of paper machine. The degree of improvement varied, but no negative effect has been observed in these cases. Increased contamination on inner rolls, etc. which might be expected, has not shown up. Figure-3 shows examples of suitable positions for the HPS in a Fourdrinier and a twin-wire machine.

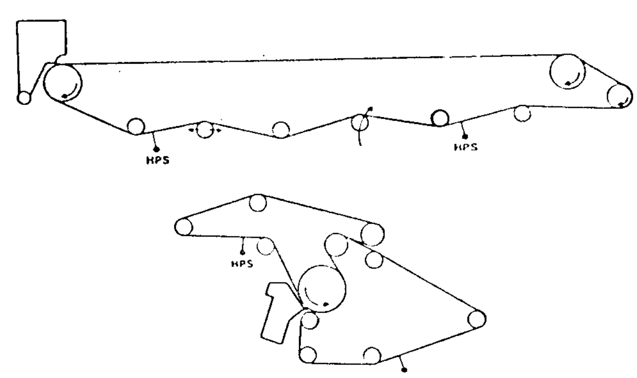


Fig.3 *Suitable locations of high-pressure cleaning showers (HPS)*

The use of the HPS from the outside of the fabric has other positive effects too. Already after a short running time, the back side of the fabric will be more or less worn. When the shower is located inside the fabric, the jets will thus hit worn monofilament threads. These are much more sensitive to fibrillation damage than unworn ones. As the paper side of the fabric is worn much less than its back side, the advantage of having the shower located outside the fabric is evident.

During damage tests of different fabrics it was found that many fabric styles have a considerably higher resistance against fibrillation damage on their paper side compared to their back side (not worn ones) Coarse fabrics have higher resistance against damage than fine ones. Damage was observed both on yarns in the machine direction and in the cross direction

The location of the HPS also influences its mainttenance and operation. With the shower on the out side of the fabric, the nozzles will in general point upwards, which substantially decreases the risk of plugging from impurities in the water. This matter has been confirmed at many mills where the HPS has been change from the inside to the outside.

Type of nozzle-needle or fan

It could be expected that different types of nozzles could give different cleaning results. Needle jet nozzles (dia. 1.0 mm) and fan nozzles (dia. 1.0 mm, 15°) were compared with each other as regards cleaning efficiency. The two types have the same water consumption at equal pressures, but the needle jet nozzles were found to be able to give a considerably higher cleaning effect as shown in Figures 4,5 & 6

At constant pressure, the cleaning effect is very dependent on the distance between nozzle and fabric. However, there is at least one distance for which the needle nozzle shows much higher cleaning effect than the maximum effect of the comparable fan nozzle. For this reason, further results will be reported in this paper only for needle jet nozzles.

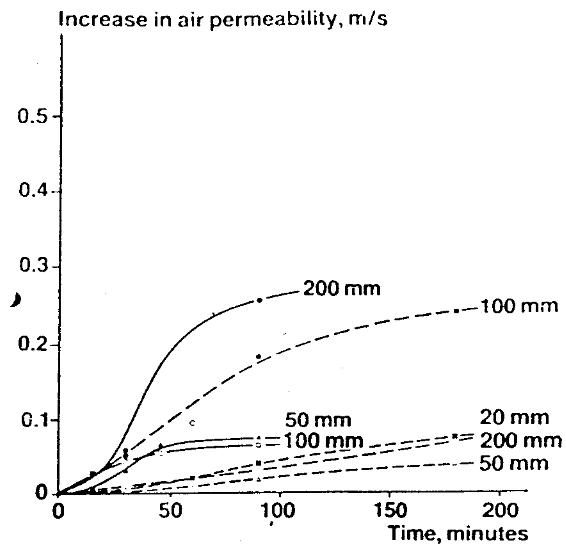


Fig. 4 *Increase in air permeability versus cleaning time at different distances between fabric and shower by use of needle nozzle and fan nozzle (15).*
Synthetic contamination (epoxy resin mainly on the paper side of the fabric) Water jet against paper side
Pressure 3 MPa
Nozzle diameter 1.0 mm
Fabric DUOTEX A4, double-layer, 7 shaft
——— *needle nozzle*
— — — *fan nozzle (15)*

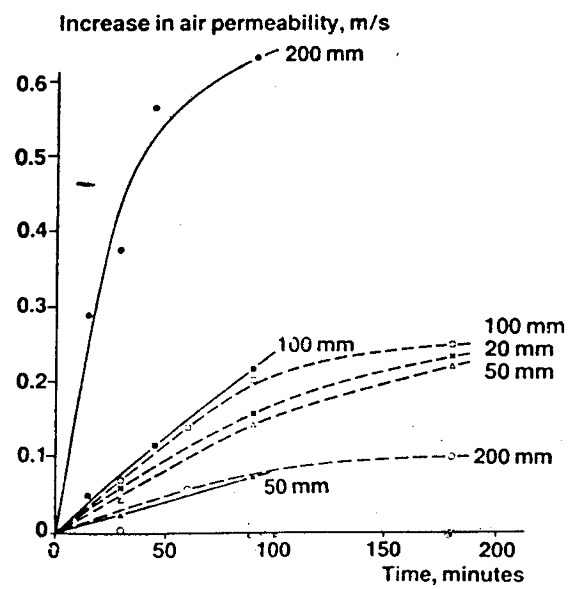


Fig. 5 *Increase in air permeability versus cleaning time at different distances between fabric and shower by use of needle nozzle and fan nozzle (15).*
Synthetic contamination (epoxy resin mainly on the paper side of the fabric). Water jet against paper side.
Pressure 4 MPa
Nozzle diameter 1.0 mm
Fabric DUOTEX A4, double-layer, 7 shaft
——— *needle nozzle*
— — — *fan nozzle (15)*

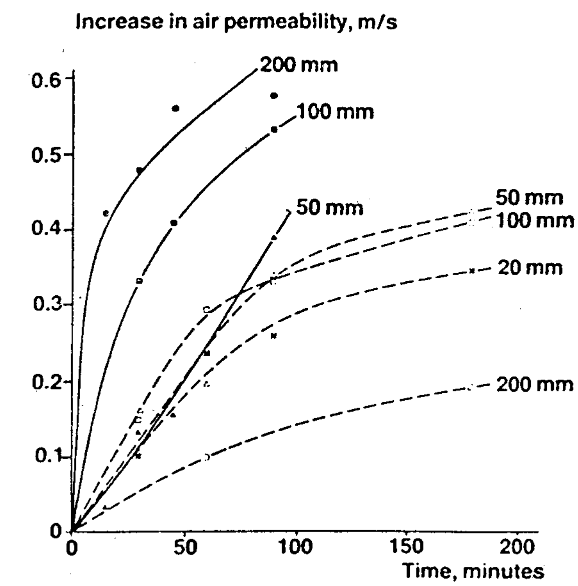


Fig. 6 *Increase in air permeability versus cleaning time at different distances between fabric and shower by use of needle nozzle and fan nozzle (15).*
Synthetic contamination (epoxy resin mainly on the paper side of the fabric) Water jet against paper side.
Pressure 5 MPa
Nozzle diameter 1.0 mm
Fabric DUOTEX A4, double-layer, 7 shaft
——— *needle nozzle*
— — — *fan nozzle (15)*

Distance—shower to fabric

A common opinion is that the distance between the HPS and the fabric is of minor importance as regards cleaning effect. However, the tests showoed that this parameter is one of the most important ones. Up till recently the most commonly used distance between shower and fabric has been in the 50 to 150 mm range. In the study, distances between 50 and 600 mm were evaluated for needle jet nozzles. Perhaps surprisingly, the tests showed that the most effect've cleaning is obtained in the 200-400 mm range. At a very short distance, e.g. 50 mm, the cleaning effect is minute and then increases and reaches its maximum in the 200-400 range. At still greater distances, the effect decreases again. Photographs of the jet showed that it started to disintegrate in the 150-200 mm range (at 4.0 MPa). By doing this, the jet is changing its appearance from being a mainly laminary flow to a flow of droplets that have a hammering and vibrating effect on the fabric and on single monofilaments. An example of the influence of distance on the cleaning effect is shown in Figure 7. The distance to distintegration of the jet could, of course, vary due, for instance, to nozzle construction, surface roughness and pressure, but there will still be a very important relationship between cleaning effect and distance. Unfortunately, the maximum damaging effect for needle jet showers is in the 200-400 range This is well illustrated in Figure 8 for a single and a double-layer fabric. However, assuming that the shower is located outside the fabric (against the paper side), the time to fibrillation damage will in general will exceed the life of the fabric. The distance between the shower and the fabric has thus a decisive influence on the cleaning effect and it is consequently one of the most important parameters when optimizing high-pressure shower application.

Nozzle diameter

The influence of nozz'e diameter and water pressure on water consumption is well known for needle jet showers. Nevertheless, it is shown for the most commonly used diameters of 0.7, 1.0 and 1.4 mm in Figure 9. As fresh water is generally used for this type of shower, consumption costs should not be overlooked. In the tests, the diameters of 0.7 and 1.0 mm gave almost the same water consumption (Fig. 10) for equal cleaning effect. A larger diameter (1.4) increased water

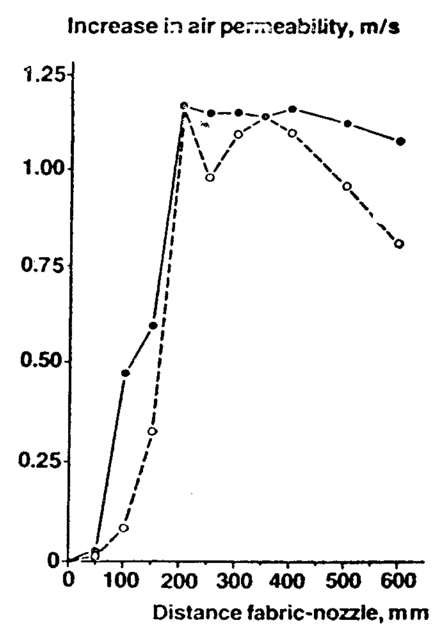


Fig. 7 *Increase in air permeability versus distance between fabric and needle jet nozzle. Synthetic contamination (mainly on paper side). Pressure 3 MPa.*
Nozzle diameter 1.0 mm.
Fabric tension 6 kN/m.
Fabric DUOTEX A4, 7 shaft, double-layer
Time 15 --o-- and 30 —•— minutes against paper side

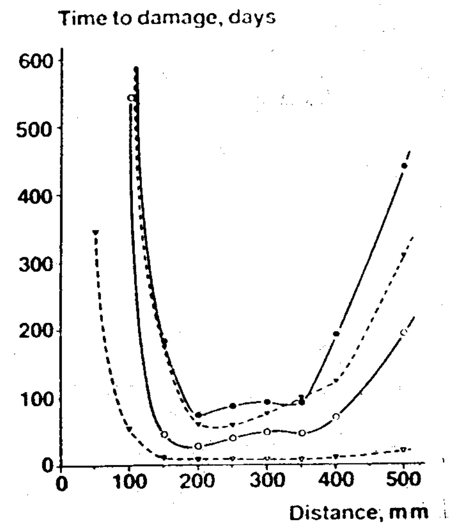


Fig. 8 *Time to damage versus distance (1 nozzle/m²)*
Pressure 5 MPa
Nozzle diameter 1.0 mm
Fabric tension 6 kN/m
Fabric single-layer MONOTEX K3, jet against paper side —●—
Fabric single-layer MONOTEX K3, jet against back side —o—
Fabric double-layer DUOTEX A4, jet against paper side --▼--
Fabric double-layer DUOTEX A4, jet against back side --▽--

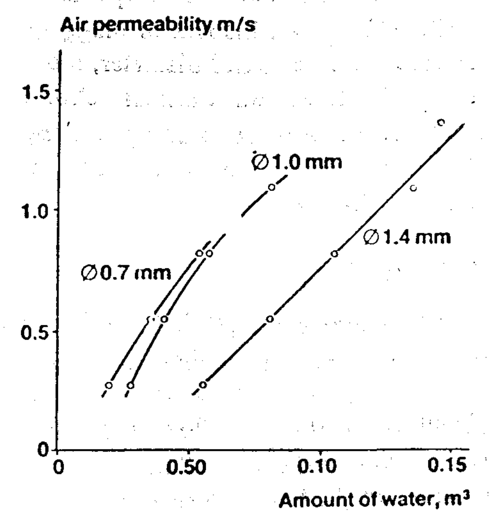


Fig. 10 *Air permeability versus amount of water with different nozzle diameters.*
Pressure 3 MPa
Distance 100 mm
Fabric MONOTEX K3, 5 shaft, single-layer

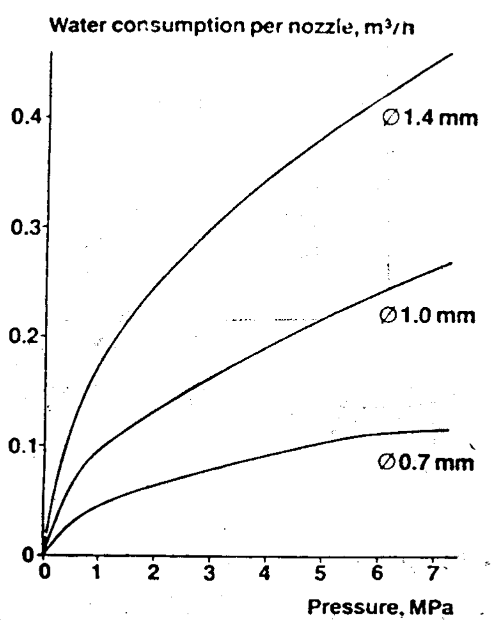


Fig. 9 *Water consumption versus pressure with different nozzle diameters.*

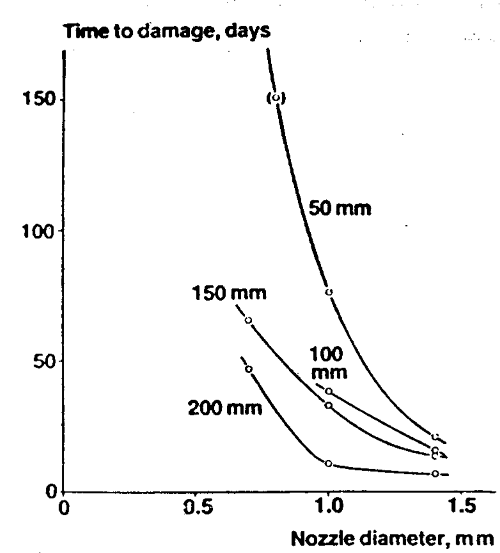


Fig. 11 *Time to damage versus nozzle diameter at different distances*
Pressure 5 MPa
Fabric tension 6 kN/m
Fabric DUOTEX A4, 7 shaft, double-layer

consumption without a corresponding increase in the cleaning effect. As the risk of plugging of the nozzles increases with decreased diameter, a diameter of about 1.0 mm should be an optimal choice. Fortunately, this choice seems to be of advantage regarding the damaging effects too as they were found to increase with increased diameter (Fig. 11).

Water pressures

Water pressure is probably today the most commonly used parameter to influence the cleaning result. From experience it is known that pressure has considerable effect on the efficiency of the shower. This was also confirmed in the investigation. As regards the cleaning effects, it was shown that pressures lower than 2-2.5 MPa generally give very small cleaning effects, which is illustrated in figure. 12 for three different nozzle diameters. when such low pressures are used, the water consumed could be regarded as more or less wasted. This is illustrated in Figure 13 where the cleaning effect versus consumed amount of water is shown for different pressures. Hence we conclude that water consumption for a given cleaning effect decreases with increasing pressure. However, increased pressure will also considerably increase the risk for fibrillation damage of the fabric as shown in figure 14 for a medium coarse single-layer fabric. Therefore, pressure higher than about 4 MPa should be avoided.

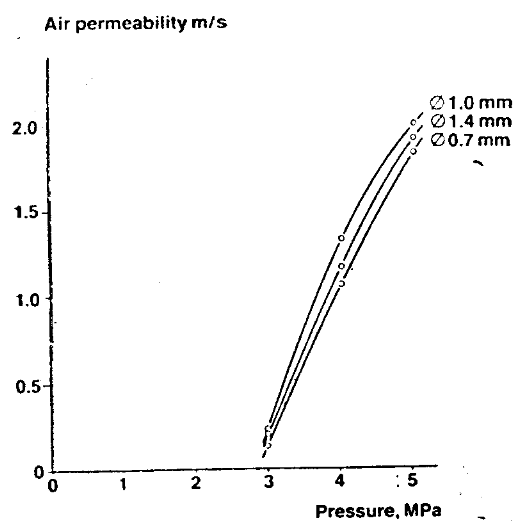


Fig. 12 *Air permeability versus pressure with different nozzle diameters*
Time 10 min
Distance 100 mm
Fabric MONOTEX K3 5 shaft single-layer

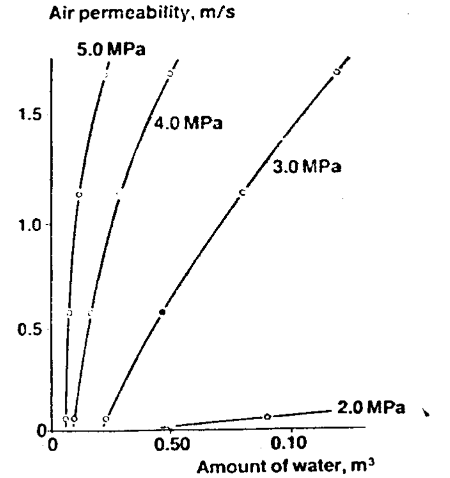


Fig. 13 *Air permeability versus amount of water at different pressures*
Distance 100 mm
Nozzle diameter 1.0 mm
Fabric MONOTEX K3, 5 shaft, single-layer

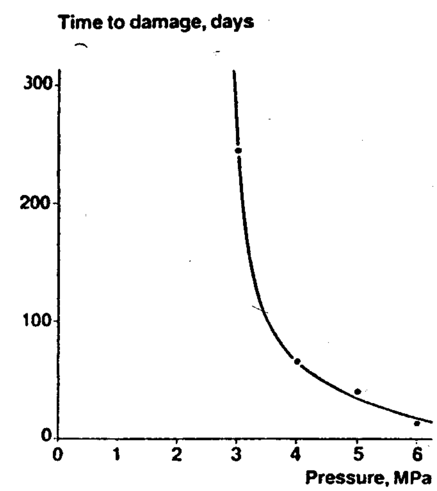


Fig. 14 *Time to damage versus pressure with 1 nozzle/m²*
Jet against paper side.
Distance 200 mm
Nozzle diameter 1.0 mm
Fabric tension 6 kN/m
Medium coarse MONOTEX single-layer fabric.

Jet angle and fabric speed

The jet angle in the machine direction can generally be varied by turning the shower tube. In order to evaluate this parameter, some tests were carried out with the jet hitting the fabric perpendicularly and at 60°. All tests showed that the highest cleaning effect was obtained with the jet prependicular to the fabric. If these observations are assumed to be correct, the shower tube has to be turned to a specific degree, depending on fabric speed, in order to get the active jet velocity vector perpendicular to the fabric. For slow running machines, the shower nozzles could point perpendicularly to the fabric as jet velocity will be considerably higher than fabric speed. However, at machine speeds exceeding 10-15 m/s, a correction should be made by turning the shower tube in the running direction of the fabric, resulting in a jet having an angle smaller than 90° to the fabric. Suitable angle settings for different fabric speeds are shown in figure 15. A setting according to this figure will also minimize the water splash of the jets. On the other hand, if the shower jet is set against the running direction of the fabric, a greater part of the jet will be reflected back by the fabric. Such a setting will decrease the risk for contamination inside the fabric loop. but probably at the sacrifice of a somewhat lower cleaning effect.

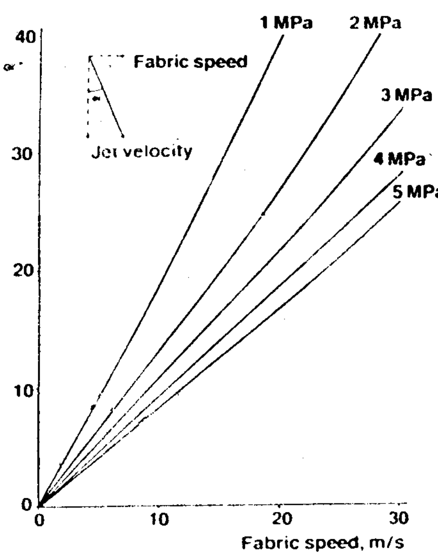


Fig. 15 *Influence of fabric speed on jet angle resulting in a jet velocity vector perpendicular to fabric surface*

Shower oscillation

In most cases the oscillation of the HPS is not matched to the length or speed of the fabric. This results in uneven conditioning, i.e. some points of the fabric are hit many times and others only once or not at all. HPS equipment is now available on the market (Albany International, Engineered Systems Division) with a variable speed drive to enable oscillation to be matched to fabric revolution. This means that the oscillator moves, for instance, one millimetre per fabric revolution and thereby cleans the whole fabric once per shower oscillation.

Installations in paper machines have dramatically improved cleaning and reduced water consumption.

Fabric tension

Fabric tension has to be kept within pretty narrow limits in the paper machine for different reasons. In spite of this, the influence of fabric tension on the risk of damage was evaluated for a fabric. The results are shown in Figure 16. The risk for fabric damage is greater at a low tension than at a high one. This observation agrees well with the theory that fibrillation damage is caused by high-frequency vibrations of single monofilaments. The fibrillation itself could then be a result of bending fatigue. A higher tension of the filament will then result in a higher resonance frequency and smaller amplitude, and less damage.

Fabric construction

As polyamide often is used in the cross-machine (CD) direction in order to improve wear resistance, some tests were performed with a double-layer fabric with alternating polyester and polyamide on the back side.

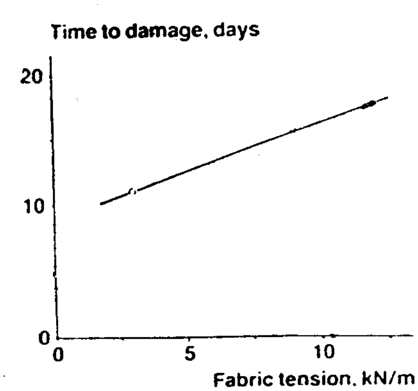


Fig. 16 *Time to damage versus fabric tension (1 nozzle/m²)*
Pressure 6 MPa
Distance 100 mm
Nozzle diameter 1.0 mm
Fabric DUOTEX A4, 7 shaft, double-layer

The polyester threads in the cross direction were totally destroyed by fibrillation. The polyamide ones were not fibrillated, but were worn against the warp threads. Also, this strengthens the theory that fibrillation damage is caused by vibrations of the filament threads. As polyamide has a much higher flex and bending resistance than polyester, the polyester threads will be destroyed first.

Conclusion

- Locate the shower outside the fabric against the paper side.
- Use needle nozzles, not fan nozzles.
- The nozzle diameter should be approximately 1.0 mm.
- The distance between the nozzles and the fabric should be 200-400 mm.
- Use water pressure between 2.5 and 4 MP.
- Locate the shower so that the active jet velocity vector is perpendicular to the fabric.
- Locate the shower so that the jet hits the fabric as close as possible to supporting inner or outer return roll.
- Arrange so that the oscillation speed of the HPS is matched to fabric length and speed.

PRESS FELTS

An optimum use of oscillating high-pressure showers should provide the following benefits :

Maximum cleaning and increase in bulk with :

- Minimum of water consumption
- Minimum damage to the felt
- Minimum maintenance of the showers
- Minimum power requirements

Experimental

The already described test shower was used. During the test, the cleaning effect on the samples was evaluated by measuring air permeability at a pressure drop of 100 Pa over the sample. Damage was evaluated visually.

All tests were carried out with samples taken from felts that had been run on different paper machines.

The samples were not compressed during the tests, in contrast to what happens on a paper machine. The absolute values for changes in air and caliper should therefore not be directly compared with those obtained on a paper machine. However, the tests showed very clearly what factors are the most important for optimizing the function of the showers.

All times given in the diagrams are experimental times from the tests and not shower times on a paper machine.

Distance between felt and nozzle

Needle nozzle — Results clearly show that the shower should be placed between 250 and 400 mm from the felt. At a distance below 150-200 mm, the effect of the jet is markedly diminished, especially at pressures from 1 to 3 MPa. At higher pressures (4 MPa) the jet disintegrates after a short distance (about 150 mm), as shown in the diagrams in Figures 17 and 18. A much higher effect is therefore obtained at a pressure of MPa and a distance of 400 mm than at 4 MPa and 100 mm.

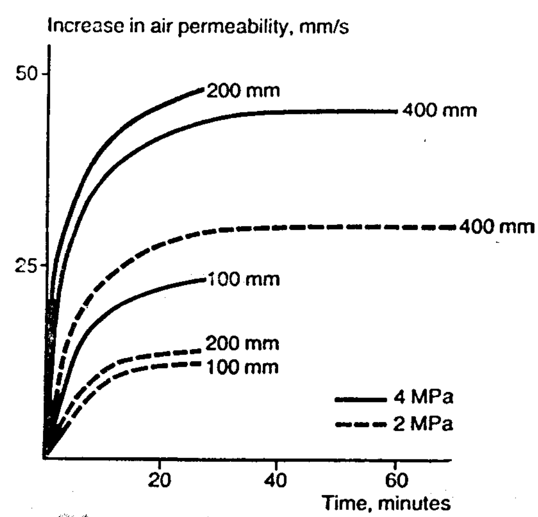


Fig.17 *Increase in air permeability versus time at different distances between shower and felt.*
Needle nozzle diameter 1.0 mm
Water temperature 10°C
Single-layer felt

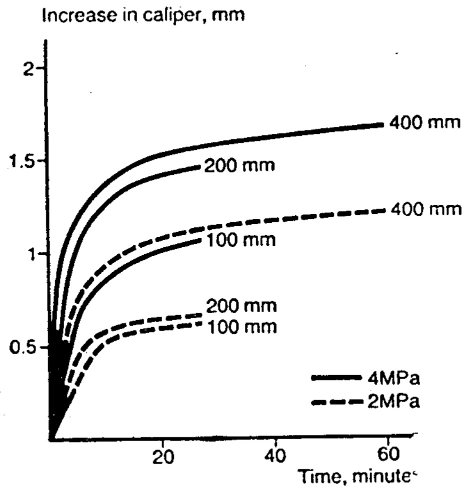


Fig.18 Increase in caliper versus time at different distances between shower and felt.
Needle nozzle diameter 1.0 mm
Water temperature 10°C
Single-layer felt

Of particular interest is the influence of distance on water consumption at a given cleaning effect. It is often possible to reduce water consumption by 50 to 70% by lowering pressure and increasing the distance. Retaining a high presse (4MPa) and changing the distance from 100 to 400 mm, while keeping the same shower time, will unquestionably lead to serious damage to the felt. When increasing the distance, pressure has to be lowered.

Fan nozzle--Tests show tha' this type of nozzle gives an optimum effect in the distance range of 50 to 100mm (Fig. 19). As has already been implied, this type, however, gives a considerably inferior effect than needle nozzles at the same pressure and with the same nozzle diameter (and water cosumption). When fan nozzles are used, only the top layer of the felt's batt is influenced. The risk for damage is small, and this means that they can be applied in positions where the uniformity of the felt's surface is of considerable importance, e.g. tissue felts.

Water pressure

water pressure has considerable influence on air permeability and bulk with needle nozzles, but little influence with fan nozzles. When using fan nozzles, it does not pay to increase pressure above 2 MPa in order to improve the showering effect.

When using needle nozzles, a certain pressure gives the felt an increase in permeability and bulk that remains on a constant level (Figures 20 and 21). Further showering does not increase air permeability or bulk, but solely increases wear on the felt. If we wish to increase air permeability even more in a specific case with intermittent showering, pressure should be increased but not showering time. Lower water consumption is obtained when using a higher pressure than a lower one for a given increase in cleaning effect.

Tests have also shown that pressures down to 0 7 MPa can have a very good effect provided the distance is 300-400 mm (Fig 22). This means that special high-pressure pumps can be omitted in many cases If the shower is applied in the correct way, there should be no further need for a pressure higher than 2 5 MPa.

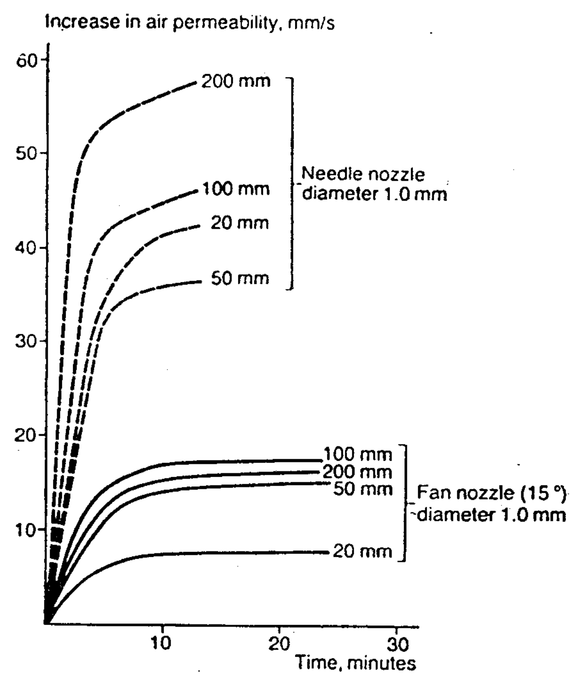


Fig.19 Increase in air permeability versus time for needle nozzle and fan nozzle at different distances between felt and nozzle.
Pressure 4 MPa
Water temperature 10°C
Used single-layer tissue felt with contaminants from secondary fibres

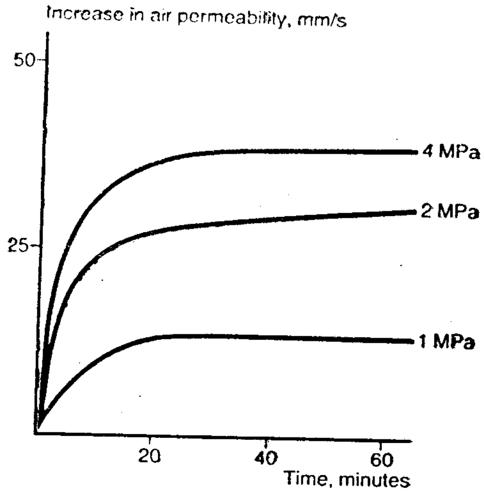


Fig.20 *Increase in air permeability versus time at different pressures*
Needle nozzle diameter 1.0 mm
Water temperature 10° C
Distance 400 mm
Double-layer felt

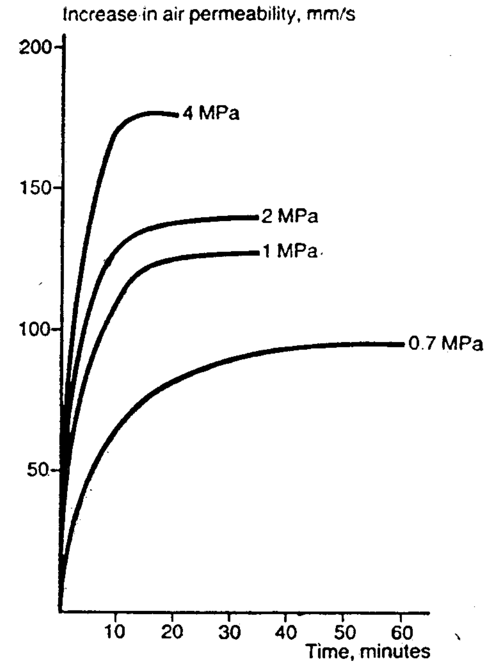


Fig.22 *Increase in air permeability versus time at different pressures.*
Needle nozzle diameter 1.0 mm
Water temperature 60° C
Distance 400 mm
Used tissue felt, double-layer style

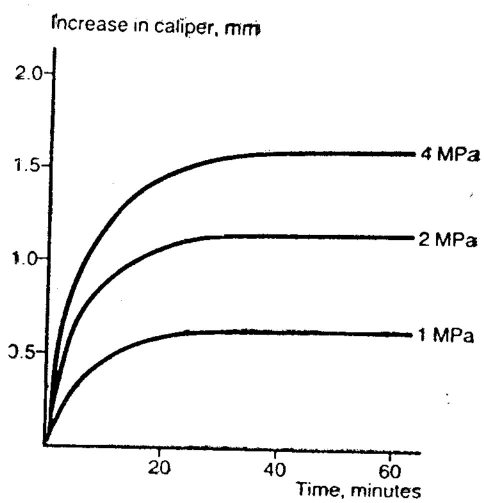


Fig.21 *Increase in caliper versus time at different pressures.*
Needle nozzle diameter 1.0 mm
Water temperature 10° C
Distance 400 mm
Double-layer felt

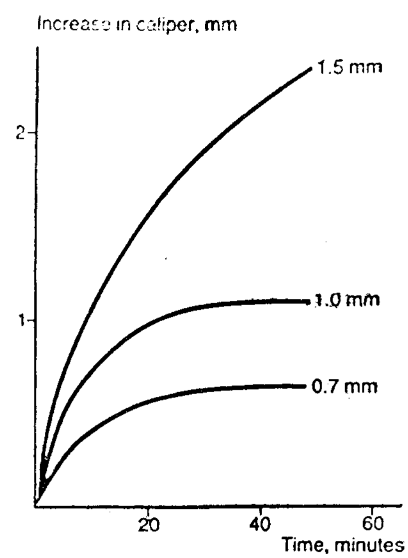


Fig.23 *Increase in caliper versus time with different nozzle diameters.*
Needle nozzle
Water temperature 10° C
Distance 400 mm
Pressure 2 MPa
Single-layer felt

Nozzle diameter

During the investigation, it was found that the diameter of the nozzle had considerable influence on the efficiency of the needle jet. An increase in diameter gave a deeper penetration by the jet in to the felt, and this gave increased air permeability and bulk. Figure 23 shows that a specific nozzle diameter gives a constant increase in bulk after a certain time. Further showering docs not increase this bulk but only causes more fibre damage in the felt. Increased pressure or larger nozzle diameter can, on the other hand, further increase air permeability and bulk.

Figure 24 shows that the largest nozzle diameter gives the lowest water consumption for a specific increase in permeability. Water consumption per nozzle and unit of time is, however, naturally greater for a large diameter than for a small one.

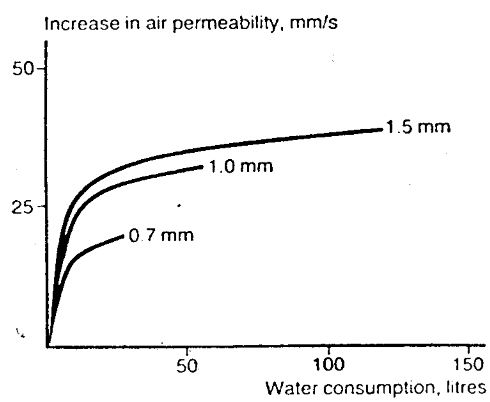


Fig. 24. *Increase in air permeability versus water consumption with different nozzle diameters.*
Needle nozzle
Water temperature 10 °C
Distance 400 mm
Pressure 2 MPa
Double-layer felt

Water temperature

The influence of water temperature on high-pressure showering was also investigated. Generally speaking, the temperature of the water should be the same in all showers and equal to the temperature of the felt. Shower water with a considerably lower temperature than the felt could lead to deposits in the felt and influence drainage negatively at the suction boxes and of the paper web.

Tests were carried out with water temperatures of 10°C and 60°C. They indicated tbat the effect of the shower expressed as increases in air permeability and bulk were generally higher at 60°C than at 10°C

Oscillating speed

In most cases, the oscillating speed of the high-pressure shower is not matched to the length of the felt or machine speed. This leads to uneven conditioning, with some parts of the felt being treated many times and others once or not at all. Oscillating and guiding equipment is available on the market (Albany International, Engineered Systems Division) in which the speed of the shower is matched to the speed of the felt. This means that the shower moves, for instance, 1 mm per felt revolution and thus cleans the whole felt once (and possibly twice, per oscillation. It has not been possible to verify if this kind of guiding could increase the risk for showering damage in the form of stripes in the felt. On the other hand, this method has given markedly improved cleaning and conditioning of the felt.

Jet angle against felt

The influence of the angle of the jet against the felt could nct be immediately evaluated with the test equipment, All tests were conducted with the jet at right-angles to the surface of the felt. On a paper machine, if we want to set the shower so that the resultant velocity of the jet is pointing at right-angles to the surface of the felt, than the jet must be aimed in the running direction of the felt at an angle dependent on the speed of the felt and the water pressure of the shower (Fig- 25). If the jet is pointing against the running direction of the felt, it will lead to a "doctoring effect", i.e. primarily working on the surface layer of the felt. If the jet is pointing in the running direction of the felt at too wide an angle, it will raise the surface of the felt (Fig. 26).

Showering time

With intermittent showering, the question is often asked about the length of time required. No exact answer can be given as this is determined from experience for each position. One suitable aid is to continuously measure the openness of the felt by, for example,

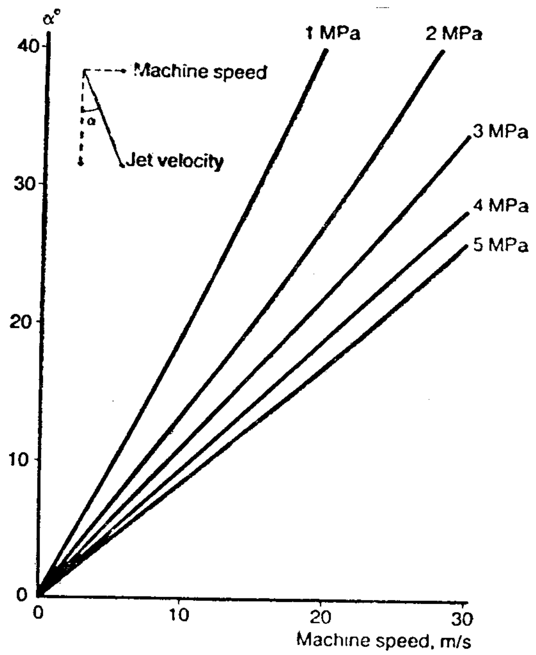


Fig.25 Relationship between machine speed and pressure to giv a resultant jet velocity perpendicular to the felt.

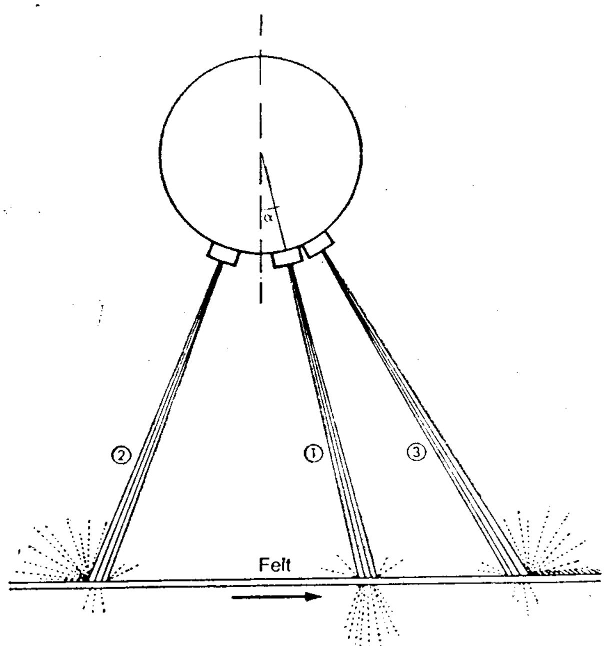


Fig.26 Results of different settings of angle α.

1. *Correct setting. The angle α is chosen so that the direction of the water drops is at right-angles to the felt. This gives maximum increase in bulk, hardly any raising of the surface of the felt, and high cleaning effect. Setting gives a minimum of water splashing.*
2. *Setting against the direction of the felt. Does not give maximum cleaning effect or increase in bulk, but neither does it raise the surface of the felt. The jet gives a "doctoring effect" and loosens contaminants lightly anchored in the surface of the felt. Increases risk for "long-haired" felt surface and fibre shedding.*
3. *Incorrect setting. Angle α is too large. Will heavily raise the surface of the felt. Does not give maximum increase in bulk or cleaning effect. Considerable risk for "long-haired" felt surface and fibre shedding.*

Parameter	Standard today	Case 1	Case 2	Case 3
Water pressure, MPa	4.0	**2.0**	2.0	**2.0**
Distance, mm	100	**400**	**400**	**400**
Nozzle diameter, mm	1.0	1.0	**1.5**	**1.5**
Water temperature, °C	60	60	60	60
Oscillating type	Standard	Standard	Standard	Controlled 2 mm/ felt lap
Relative water consumption with constant cleaning effect.	100	50	35	30
Relative time with constant cleaning effect.	100	80	50	40

Fig.27 Examples of relative water consumption and relative required time received for different cases of shower setting.

Parameter	Standard today	Case 1	Case 2	Case 3
Water pressure, MPa	2.0	**2.0**	2.0	2.0
Distance, mm	75	**400**	**400**	**400**
Nozzle diameter, mm	1.0	**1.5**	1.0	**1.5**
Water temperature, °C	20	20	**60**	**60**
Oscillating type	Standard	Standard	Standard	Standard
Relative water consumption with constant cleaning effect.	100	25	20	15
Relative time with constant cleaning effect.	100	35	30	25

Fig.28 Examples of relative water consumption and relative required time received for different cases of shower setting.

measuring the air flow in the outgoing pipe of a suction box. With this type of measuring, it is possible to follow the permeability of the felt when showering is in operation and also between showering intervals.

Results

Figures 27 and 28 are examples of alternatives for positioning and setting the shower. Water consumption can be reduced by 50 to 70% by a simple means while retaining the conditioning effect.

As a summing-up three alternative recommendations, two with needle nozzles and one with fan nozzles, are given.

Recommendations

Alternative 1

High-pressure shower with needle jet on the paper side of the felt.

Purpose	To keep the paper side of the felt free from contaminants without causing negative effects such as fibre raising, shower stripes or other forms of unevenness in the surface of the felt. The shower does not penetrate deeply in to the felt and therefore influences mainly the top batt layer of the felt. Should be suitable for tissue and sensitive pick-up felts. This shower is far more lenient on the felt than the shower in Alternative 2. If a pronounced increase in the openness or bulk of the felt is required, Alternative 2 can be used. If paper quality or felt runnability do not allow such heavy showering on the paper side of the felt, the shower should be placed on the back side instead.
Distance from felt to nozzle	300-400 mm (reduced distance will give a successive reduction in cleaning effect).
Time	Can be used continuously.
Pressure	0.7-1.2 MPa (7-12 kp/cm2).
Nozzle diameter	0.7 mm, maximum 1.0 m (risk for damage increases markedly with increased diameter).
Distance between nozzles	75 mm
Oscillating length	150 mm

Alternative 2

High-pressure shower with needle jet on the paper side of the felt.

Purpose	To keep the paper side and the baseweave of the felt free from contaminants and at the same time increase the bulk of the felt (i.e. opening up the baseweave and the batt on the paper side).
Distance from felt to nozzle	250-400 mm (reduced distance will give a successive reduction in cleaning effect).
Time	Should be used intermittently. Time is dependent on the degree of plugging and felt type, often 20-40 minutes every 8 hours.
Pressure	1.2-2.0 MPa (12-20 kp/cm²).
Nozzle diameter	1.0 mm, maximum 1.5 mm (increased diameter will give pronounced increased effect).
Distance between nozzles	75 mm
Oscillating length	150 mm

Alternative 3

High pressure shower with fan jet on the paper side of the felt.

Purpose	To keep the paper side of the felt free from contaminants without causing negative effects such as fibre raising, shower stripes or other forms of unevenness in the surface of the felt. The shower does not penetrate the felt very much. This recommendation can be used as an alternative to Alternative 1 (higher water consumption than Alternative 1). Suitable for tissue felts. If it is necessary to markedly increase the openness and bulk of the felt, Alternative 2 should be used intermittently. If paper quality or felt runnability do not allow heavy showering on the paper side of the felt, the shower should, in such a case, be placed on the back side instead.

Distance from nozzle	75–100 mm
Time	Should be used continuously
Pressure	2.0-2.5 MPa (20-25 kp/cm²)
Nozzle diameter	1.0-1.2 mm
Distance between nozzles	75 mm
Oscillating length	150 mm

DRYER FABRICS

Contaminants in dryer fabrics come mainly from the furnish and its additives, and/or from coating or size press chemicals. The method and cleaning programme should therefore be based on identifying the type and degree of contamination. Based on experince, contaminations found in dryer fabrics can be classified into four main groups.

1) Dust

Consists mainly of short cellulose fibres.

2) Organic substances that are not cross-linked

— pitch

— tar, asphalt, wax, often from a furnish based on recycled pulp

— size from the size press of the CMC, starch and cassein types

— oil and grease from bearings

3) Cross-linked organic substances

— Wet-strength resins

— coating chemicals based on latex (SBR, acrylic, etc.)

4) Non-organic substances

— alum, kaolin, titanium dioxide, calcium carbonate, scale and rust

Results from an investigation of a number of returned fabric samples (Table 1) show that permeability can be drastically reduced after a short time in the machine. The amount of contamination can be quite small, yet despite this cause pronounced reduction in permeability.

Very pronounced contamiation is quite common after size presses and coating positions. It is not unusual for dryer fabrics to be completely plugged, and then often in streaks.

Grade	Position	Running time – months	Permeability m/s (m/h) New	Permeability m/s (m/h) Used	Plugging in % Extracted material	Plugging in % Pulp	Plugging in % Ash content
Newsprint	2 SR	8	0.3(1080)	0.2(540)	1.4	1.6	1.6
Newsprint	2 bottom	4	0.5(1800)	0.1(270)	0.9	1.1	0.4
Magazine	3 top	12	1.1(4000)	0.8(2700)	1.0	1.9	2.2
Magazine	3 top	16	0.8(3000)	0.2(560)	4.6	5.9	1.3
Kraft	3 bottom	12	2.5(9000)	1.5(5360)	5.3	4.8	3.6
Kraft	2 bottom	13	2.5(9000)	2.0(7300)	4.2	2.8	1.7

Table I. Examples of plugging of fabrics.

Cleaning method	Contamination
Air shower	Cellulose fibres, filler particles.
Water shower (high pressure)	Cellulose fibres, coating and size press chemicals, pitch.
Steam shower (high pressure)	Pitch, asphalt, rosin size, cellulose fibres, alum, clay, titanium dioxide.
Hot water (low pressure)	Size press chemicals (water soluable).
Chemicals (low pressure)	Grease, oil, size, wax, latex, asphalt.
Brush	Cellulose fibres and large clumps of contaminants on the surface of the fabric such as stickies, wax, latex, etc.

Table II. Cleaning methods for different types of contaminants.

Influence of fabric design

A fabric consisting only of monofilaments has a surface and a structure that stay clean. This is also the easiest type of fabric to clean. Dryer fabrics consisting entirely or partly of multifilaments, spun yarns, or with a needled surface tend to plug much quicker.These kinds of fabrics are also far more sensitive to damage during cleaning with, for instance, showers. Needled dryer fabrics should not be cleaned at all during production because of the risk of fibre release. Practical experience has also shown that combinations of polypropylene/polyester monofilaments are preferable to ones of 100% polyester. Monofilaments with an extremely hydrophobic surface, such as teflon, can have a positive effect in positions after the size press.

Experimental

The test shower was used and double-layer dryer fabrics were examined. In order to simulate contamination of the fabrics, a number of fabrics that had been run in paper machines were tested.

The cleaning effect was measured on dry samples visually and by measuring air permeability at a pressure drop of 100 Pa with a portable permeability meter (Valmet).

Cleaning with an air shower

When cleaning with an air shower, we recommend a regular and periodic application. This method is best suited for cleaning fabrics with a high permeability that have been plugged up with fibre dust or loose dirt particles. The air shower is often insufficient for removing resins and sticky particles from dryer fabrics manufactured with a low permeability. We recommend showering with water or steam for this kind of fabric.

High-pressure showers should be placed so that the loosened dirt can be directed towards the exit duct in the dryer hood or down into the pit so that it does not whirl around in the dryer hood.

Distance between nozzle and fabric

The cleaning effect is markedly influenced by the distance between the nozzle and the fabric. The effect is more pronounced when a short distance is used. At long distances, the air jet loses a great deal of its energy (Fig. 29.) For space and safety reasons, the shortest distance is often about 30 to 50 mm.

Air pressure

The results unanimously show increased permeability when pressure is raised. It is also worth noting that a far too low pressure - 0.2 MPa - gives a very poor cleaning effect.

Nozzle diameter and nozzle type

Studies show that the diameter of the nozzle has little effect on cleaning results. When using diameters of 2.5 and 4 0 mm, no apparent differences in cleaning effect were obtained. To avoid unnecessary large air consumption, we recommend an interval of 2.5-3.0 mm. We could not see any difference between a jet nozzle and a De Laval nozzle.

Position of air shower

Showering tests with air showed that cleaning results were just as good regardless of whether the shower was directed against the paper side of the sheet or against its back side. This does not apply when showering with water or steam. When installing an air shower, a position should however be found where the dust can easily be removed from the dryer section (Fig. 30).

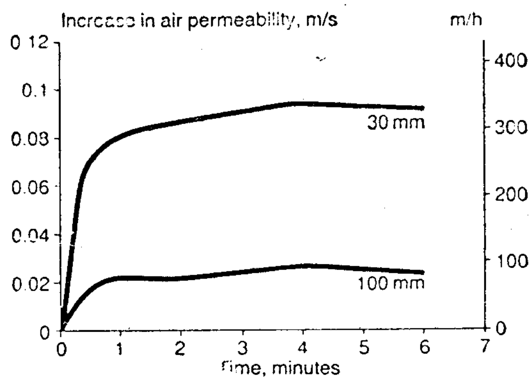


Fig.29 *Increase in air permeability for a plugged up dryer fabric versus cleaning time when cleaning at different distances between fabric and nozzle.*

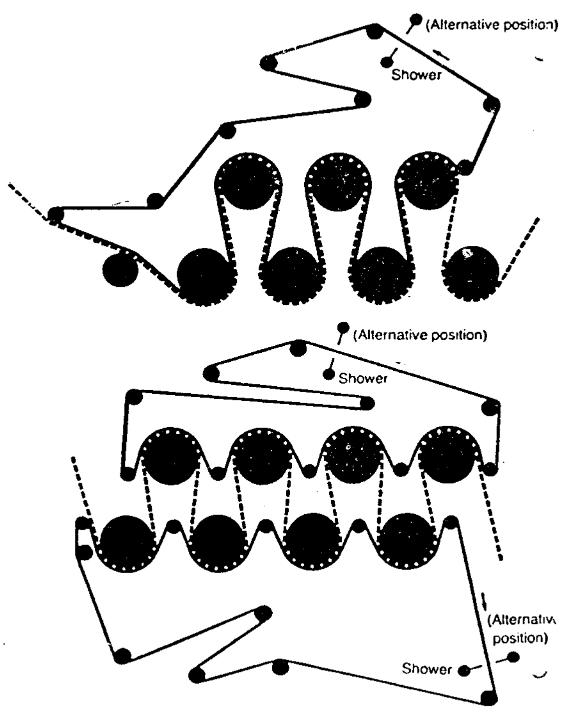


Fig.30 *Suitable positions for shower equipment when cleaning with air in a conventional run and in a single-run position (SR).*

High-pressure showering with water and water +air

Water - Oscillating high-pressure showering with water is normally carried out at a sheet break or during a shutdown. Cleaning during a shutdown should be done at the highest possible speed to avoid streakiness when cleaning. It is important for the fabric to be completely dry before paper is produced again.

When cleaning with a high-pressure shower with water, we recommend a jet nozzle. In most cases, a tray is necessary for collecting the dirt and water on the opposite side of the fabric.

Laboratory investigations and practical experience show improved cleaning results with raised water temperature (60-85°C). Experience has also shown that **the use of hot water (80-85°C) can allow high-pressure showering also when producing paper and without giving rise to problems of wet streaks.**

Water+air—A common cleaning method is the combination of high-pressure showering with water and air. The water shower first removes the contaminant, and the subsequent air shower removes foremost the water so that the fabric will be dry when it contacts the sheet again. This cleaning arrangement normally consists of two nozzles that operate across the width of the fabric. This method allows continuous cleaning during production. It should, however, be borne in mind that optimum adjustments of the nozzle diameter and the distance to the fabric differ from each other regarding air nozzles and water nozzles. The risk of wet streaks can be minimised by using hot water. **With water temperatures in the range of 80 to 85°C, it is, in certain cases, not necessary with any subsequent air showering.**

Nozzle diameter and nozzle type—Nozzle diameter was 1 mm in all cases. Earlier investigations of the cleaning of press felts and forming fabrics have shown that increased nozzle diameter gives increased cleaning efficiency. However, a medium-sized nozzle (1 mm) should be chosen to avoid wet streaks. The earlier tests on press felts and forming fabrics showed that a jet nozzle has a superior cleaning effect compared with a fan-type nozzle.

Distance between fabric and nozzle—When high pressure showering with water, the distance between the fabric and nozzle is of the utmost importance. Investigations showed that this should be 200 to 300 mm for optimum cleaning. The laminar water jet begins to disintegrate in the area of 150-200 mm. Small droplets are formed and hit the surface of the fabric. The hammering effect that is then obtained gives an obviously better cleaning effect compared with the laminar flow at shorter distances. Too short a distance will again give a low effect (Fig. 31).

Water Pressure—Increasing the pressure is perhaps the most effective way of improving the cleaning result when using a water shower. At a perssure above 4 MPa, however, there is a greater risk for damage to fabrics containing, for example, spun yarns.

Position of water shower—The position of the water shower in the dryer section is of major importance for the cleaning effect and for efficient production. Tests clearly showed that a high-pressure shower with water should always be placed on the paper side of the fabric, if this is possible. If the shower is placed on the back side of the fabric, a large amount of the jet's energy will be lost when it penetrates the fabric. The shower should be placed as early as possible in the return section of the machine (Fig- 32).

Washing with hot water (low pressure during shutdown)

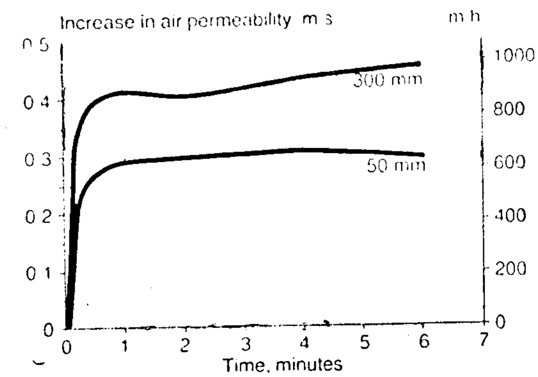
In position after the size press, fabrics can be effectively cleaned solely with hot water at low pressure during a shutdown. Fabrics in both the top and bottom positions can be cleaned solely with a shower installed in the top position (Fig. 33). Substantial amounts of water (50-80°C) are sprayed with a low-pressure shower on to the fabric, thereby loosening the contaminant, which then fastens to the heated cylinders (about 100°C). The deposit can then easily be removed by doctor blades.

It is of advantage to install the shower pipe at an incline and with a drainage outlet so that drops from the showers are avoided after washing is completed.

Figure 34 shows an alternative arrangement of the showers when cleaning with water or chemicals at a low pressure. The collecting tray on the opposite side of the fabric can be an advantage, but is not always necessary.

Cleaning with steam

High-pressure cleaning with steam is a relatively new and attractive cleaning alternative for dryer fabrics. The advantage with steam is that a very good



Cleaning from paper side
Nozzle diameter 1 mm
Pressure: 2 MPa
Dryer fabric Kraft, 13 months running time

Fig.31 *Increase in air permeability versus time at different distances between fabric and nozzle.*

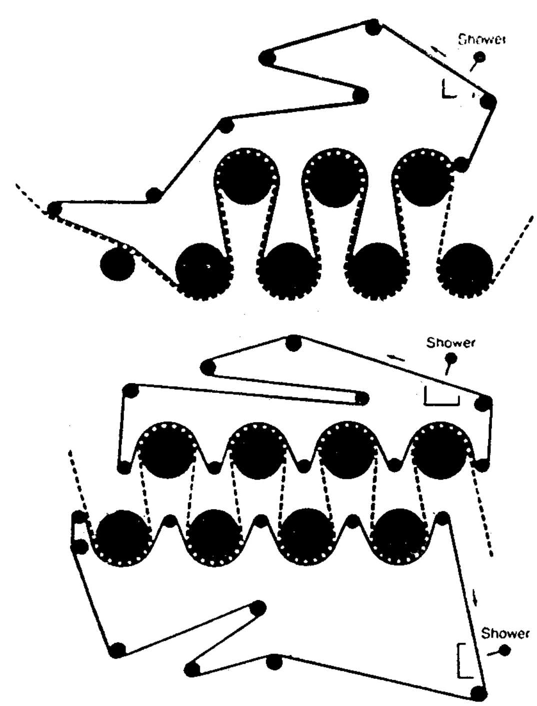


Fig.32 *Suitable position of showers when cleaning with water, [illegible] [illegible]nation of water and steam in a conventional [illegible] in a single run position (SR).*

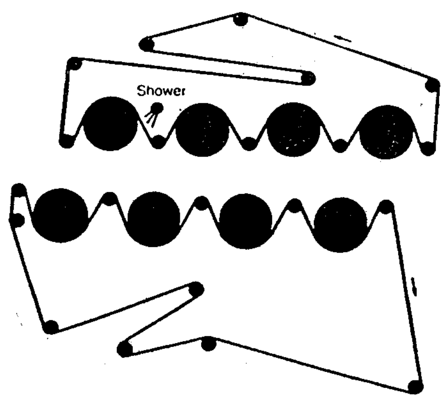


Fig.33 Position of a shower with simultaneous washing of both top and bottom fabric.

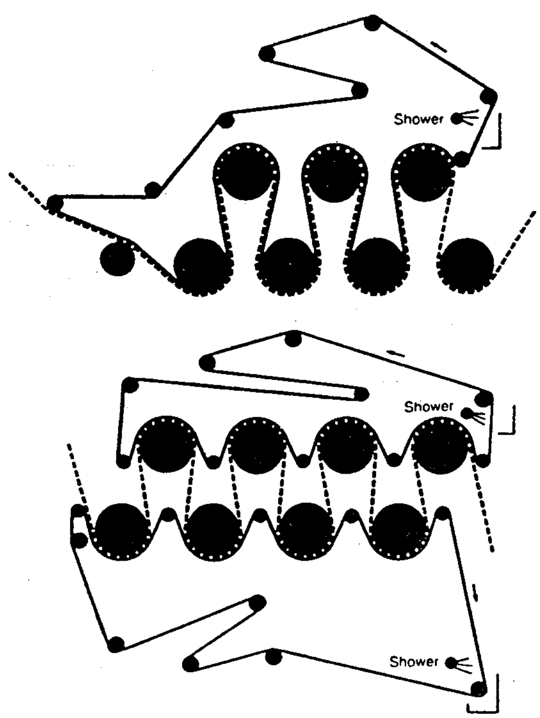


Fig.34 Alternative arrangement of showers when cleaning with water or chemicals.

cleaning result can be obtained without feeding the fabric with large amounts of water. This means the method can be used periodically during production, shutdown, or sheet break.

Pressure

A constant pressure of 0.5 MPa was used in all tests. This ought to be a suitable pressure where availability, economic requirements and safety measures are concerned.

Distance between fabric and nozzle

When using steam, the distance between the fabric and the nozzel should be carefully set. With a pressure of 0.5 MPa, the best result was achieved with a distance of 50 mm. A shorter distance produced an inferior result. When distances were too long, the jet lost its energy (Fig. 35).

Nozzle diameter

Laboratory tests showed that nozzle diameter has considerable influence on the efficiency of the shower. In practice, it is, however, uneconomic to use too large a diameter, a suitable diameter being 4-6 mm.

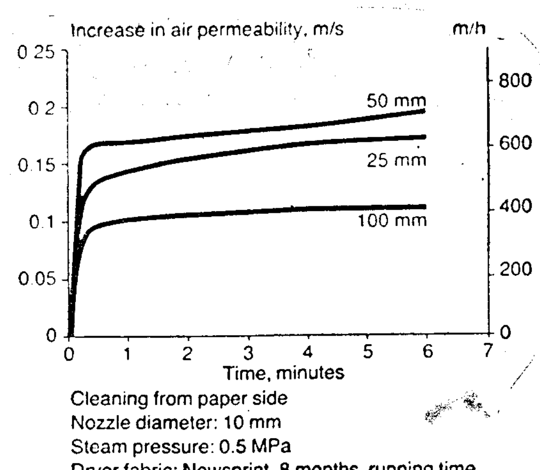


Fig.35 Increase in air permeability versus time for different distances between fabric and nozzle.

Position of shower

The position of the steam shower is very important. For the best effect, the steam ought to be applied from the paper side as in the case with water.

Parameter	Recommendation
Air	
– distance	30–50 mm if practically possible
– pressure	0.5–0.7 MPa
– nozzle diameter	2.5–3.0 mm
– position	paper side or back side
– nozzle type	jet
Water	
– distance	200–300 mm
– pressure	4–5 MPa
– nozzle diameter	1 mm
– position	paper side
– nozzle type	jet
– temperature	70–85°C
Steam	
– distance	50 mm
– pressure	0.5 MPa
– nozzle diameter	4-6 mm
– position	paper side
– nozzle type	jet

Table III. Setting of parameters when cleaning with air, water and steam.

Recommendation

A general comparison between different methods shows that high-pressure showering with water, water/air, or steam is far more effective than cleaning with an air shower. Cleaning with chemicals, which is necessary with difficult contaminations, is very effective in most cases.

However, it should be borne in mind that the choice of cleaning method should be based on the type of contamination, among other things. In many cases, even air showering ought to be a sufficiently effective method.

Table III lists the recommendations that have been drawn up on the basis of the results of the investigation.

References :

The technical Paper submitted is based on our own work and given in three Brochures about High-Pressure Showering.

1. High Pressure showers in Forming Section-publication Date September-1983.
2. Cleaning Press Felt with High Pressure Showers-Publication date December–1989.
3. The Cleaning of dryer Fabrics-Publication Date February-1991.