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ENERGY ASPECTS ON MODERN PAPER MACHINE CLOTHING

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Energy choices in pulping

When manufacturing pulp for papermaking, there are two principally different ways with regard to energy consumption.

-- to produce a low-yield chemical pulp, where about half of the wood is lost but recuperated in the form of energy, making a modern chemical pulp mill practically self-sufficient in energy.

-- to produce a high-yield mechanical pulp at the cost of a very high energy consumption.

The choice is consequently to save wood or to save energy.

Cost structure of papermaking

Modern paper machines are becoming more and more energy efficient, but choices must often be made between energy savings and other benefits. Papermachine clothing (PMC) — although its cost in relation to the sales value of the paper produced is insignificant - plays an important role in energy considerations.

A 1986 study by Jaakko Poyry of model mills in Sweden shows that for newsprint the dominating cost is for raw material (60%), followed by energy (10%) (Figure 1). Total PMC cost (forming fabrics, press felts and dryer clothing) at SEK 50/ton, represents only 2.2% of the total manufacturing cost or 1.5% of the sales value of the paper. This is on the same level as the cost for wrapping material.

PMC consumption and cost:

Figure 2 shows the development in Sweden of the specific consumption in grammes of press and dryer clothing per ton of paper since 1961. Consumption today is only 20% of what it was in 1961!

During this period the PMC price level, in current money value, did of course increase, partly due to inflation and partly due to a much more complicated manufacturing process (Figure 3). Taking inflation into consideration, however, the cost dropped by 50%. Another way of demonstrating the trend is to compare clothing costs with the price of paper. Figure 3 shows (to the right) that the cost of press and dryer clothing dropped from 2.0 to 0.9% of the paper export price from Sweden from 1961 to 1985.

For forming fabrics no reliable statistics are available, but there are reasons to believe that the cost is in the range of 0.2 to 0.6% of the paper export price.

Water removal costs:

Figure 4 compares the cost of forming, pressing and drying of paper before and after the energy crisis in the mid 1970s. The immense increase in drying costs in 1977 is worth noting. The comparison shows a 20-times higher cost for removing water through drying than through pressing. This figure has of course gone down somewhat since then with the decreasing oil price. Whatever the actual relationship is, there is no doubt that anything that can be done to improve dry content of the sheet after the press section is extremely rewarding. Energy consumption in the forming and press sections is, however, also important.

Energy aspects on the forming section

Twin-wire formers

The rapid introduction of modern twin-wire formers, especially on printing paper machines, would not have been successful if modern synthetic forming fabrics had not been developed simultaneously. Their lighter weight and easier handling made simpler and quicker wire change methods possible. Most modern twin-wire formers use considerably less driving power. A roll former, for instance, normally consumes only 1/3rd of the power of the Fourdrinier section it replaces.

Drainage speed

In the forming section energy is used to drain the sheet and the drainage speed is highly dependent on the design characteristics of the forming fabric. Fibre support and void volume are important factors. It has been demonstrated by Helle[1] that more than a 30% difference in drainage speed can be found for the same paper stock and the same single-layer fabric (Figure 5), depending on which side of the fabric the sheet was formed. This can be explained by the considerable difference in crosswise fibre support between the two sides of the fabric.

Modern multi-layer synthetic forming fabrics normally enable a doubling of fibre support power compared to bronze wires. This result in better retention, higher drainage and improved smoothness of the paper. This has often been possible to achieve with cheaper raw materials, like replacing softwood with hardwood pulp and increasing the content of mechanical furnish as well as fillers.

With double-layer forming fabrics (Figure 6), the paper side and the back side can be designed more independently and consequently a much improved fibre support on the paper side can be achieved. Better drainage and good retention can now be combined. This advantage is, however, normally used for reduced headbox consistency and reduced initial drainage in order to gain improved formation, higher retention and reduced two-sidedness.

Drive effect and suction box vacuum

In several cases the drive effect of the wire section could be reduced by redistribution of vacuum in the flat suction boxes at the end of the wire section. In one example (Figure 7), a newsprint machine had six suction boxes with approximately the same vacuum in all of them[2]. One of the boxes was then taken out of operation and the vacuum in the remaining boxes organized in a graduated way with the vacuum in the first box reduced by 50% and that of the last box doubled. This meant a 30% reduction of vaccum used with 23% less drive effect (almost 100 kW) without spoiling sheet dryness. In other similar cases improved shee dryness was reported as well.

With triple-layer forming fabrics (Figure 8), the relation between drainage and energy consumption is very favourable. In addition, other benefits can be gained. In one Swedish paper machine making sack paper of 60-170 g/sq. m, a triple-layer fabric made a reduction of headbox consistency from 0.21 to 0.17% possible. The limit was set by the fan pump. A retention improvement of 10-12% was achieved. In addition, the cross-machine tensile strength increased by 15-20%, making the paper more square.

The reduced headbox consistency made it possible to reduce refining in the stock preparation, thus saving energy. The reduced refining resulted in improved bulk, stiffness and porosity —a better sack paper. In the wire section, the last two suction boxes increased. The drive effect of the wire section was thereby reduced by 38% or about 200 kW.

This was an example of handling more water at reduced energy consumption for the benefit of making a better paper- all made possible by modern forming fabrics.

Stock dilution

As shown in Figure 9 from FEX trials, the same strength and formation can preferably be achieved through dilution rather than through refining. (FEX is the world's most advanced experimental paper machine located at the Swedish Pulp and Paper Research Institute, STFI, in Stockholm, Sweden).

Figure 9 clearly illustrates the effects of dilution. Let us start at the point corresponding to a lip opening of 6 mm and a refining energy of 40 kWh/ton. This gives a tensile index of about 34 Nm/g and a dryness of around 42% after pressing. If the refining energy is increased from 40 to 80 kWh/ton without changing the lip opening, the tensile strength goes up from 34 to 41 Nm/g but at the cost of dryness being reduced from 42 to 36%. If, on the other hand, refining is kept at 40 kWh/ton and the lip opening increased from 6 to 18 mm, the tensile strength is improved from 34 to 45 Nm/g without any significant dryness reduction after the press section.

Using 300 kWh/ton for refining costs about SEK 50/ton in Sweden and a 10% reduction translates into a saving of SEK 5/ton. The reduced refining would also normally improve the function of the press section so that the dryness after pressing can be increased. As we know, 1% higher dryness can normally be exchanged for 4% lower steam consumption or around 5% higher production speed.

High temperature operation

Modern synthetic forming fabrics, as well as press felts, are able to operate at considerably higher temperatures than earlier and this represents very large potential energy savings. Most probably temperature conservation through the wire and press sections will be a hot topic during the 1990s.

Energy aspects on the press section

High-temperature pressing of pulp

Efficient pressing at elevated temperatures must start in the forming section. A modern design of a KMW pulp drying machine is shown in Figure 10. The water in the pulp sheet is replaced by hot water prepared with cheap energy. The couch roll is solid instead of the traditional suction couch. this means that the pulp sheet enters the press section at a high temperature, not cooled by the air flow of a suction couch. This increases the stress on the press felts, which are already working under a heavy press load. The pick-up felt takes most of the beating in this case, because it handles the largest quantity of water, which sometimes also contains residuals of bleaching chemicals. Felts made from commercially available fibre materials do not function well under such extreme conditions. Dimensional stability suffers and premature degradation occurs. Chemical modification of the fibre material is necessary. This will be dealt with in more detail later on.

High-temperature pressing of paper.

As mentioned earlier, there is a tendency also in paper mills to shut off the vacuum in the suction couch in order to maintain a higher temperature level. Quite a few steam boxes in press sections have, however, been shut off after serious accidents with exploding granite press rolls. This is no doubt only a temporary situation until roll materials replacing granite have been developed.

Let us now look at a modern newspring machine working at about 55°C in the headbox. Over the flat boxes and the couch, the temperature is normally reduced through the cooling action of huge amounts of air being sucked through the sheet. This reduces the temperature to about 35°C when entering the press section. Through the use of steam showers that temperature is often again raised to about 60°C. A good old rule of thumb says that for every 10°C increase in temperature, the dryness after the press increases by 1%. Assuming now that, insead of raising the web consistency by sucking cool air through it, we decide to blow warm moist air through the sheet. There is an abundance of such air in the dryer section. By doing so, headbox temperature at 55°C cannot only be maintained but also be increased to say 65°C. With the use of steam showers, that temperature can then eventually be raised to 80-90°C. This should enable us to reach a 3-4% higher dryness before the dryer section, using considerably less energy than today. This of course requires improved fabrics and felts compared to what are now used.

An indirect proof of the possiblities for this strategy has been given from Finland, where several high-speed newsprint machines have been able to keep their production constant after shutting off the vacuum in their suction couches. The explanation is that instead of entering the press section at about 17% dryness and 45°C with the suction couch in operation, they got about 13% dryness but at 55°C with the couch shut off. As a result of the higher temperature, the press section could achieve the same dryness before the dryer section as before.

It is also important to maintain the temperature of the press felt, which might mean felt conditioning through blowing hot air through the felts as well and possibly also enclosing the whole press section in a hood. Such a paper machine (so far theoretical), which would incorporate a twin-wire former with blow rolls rather than suction rolls, a pess section with blow felt roll conditioning, steam showers, an enclosed hood and recirculation of hot moist air from the dryer section, would not necessarily be much more expensive than today's machines, but would no doubt make considerable energy savings possible.

Two-sidedness

It is a well known fact that, after a single-felted nip, the paper is smoother on the roll side and more compressed on the felt side. Both factors contribute to the two-sidedness of the paper. In the last two nips of a Tri-Nip press (Figure 11), the bottom side of the paper is pressed once against the central roll and the top side two times against felts, resulting in a two-sided sheet. In Figure 11, the smoothness of the two sides of the paper is shown symbolically by the serrated lines and the density of the paper by the filled portions of the squares. In order to compensate for the density difference between the two sides of the paper, a separate fourth press with a felt against the bottom side can be installed (Figure 12). There are at least 45 such machine rebuilds, of which 20 are in Japan, 10 in North America, 5 in Scandinavia and 10 in Continental Europe.

In order to reach a dryness increase of 1% in such a press, only very small quantities of water (far below 10 g/sq.m) need to be removed. Reduced dryness from a fourth press goes back to re-wetting of the paper from the felt, which runs wet from shower conditioning. Dryness increases have been reported in some cases:

0.5-3.0% for uncoated papers
1.0-3.0% for newsprint/LWC.

In order to finally remove the very small quantity of water in question, it is important to economise with every drop of water in the press section. Such measures are to remove lubrication showers in suction rolls using sealing of graphite/silicon and not leave any uncontrolled water on the shell. It is also recommended to use doctors on all press rolls in order not to leave any water film in recirculation to the press nip. Oscillating needle-jet showers to maintain the porosity and bulk of the felts are used only during short periods. In the fourth press, showers and suction boxes are only used temporarily for felt cleaning. The very small quantity of water needed to increase the dryness of the paper may leave the fourth press felt as a mist when it turns around felt rolls.

This situation creates increased demands on the felts, especially on the fourth press felt, which first of all is responsible for a smooth bottom side of the paper at high press loads. In order to save energy in the dryer section through increased dryness after the press section, it also has to act as a check valve against rewetting and maintain its prosity and bulk with very little felt conditioning.

The transversal flow press:

The development of today's efficient paper machines was made possible by the rapid technical development of press clothing during the last 25 years. Modern press felts allow much higher press loads and machine speeds, also on very wide machines. An important step in this development was the change-over from woven felts made of wool to needled felts of synthetic fibres. The introduction of monofilaments — single as well as plied- in press clothing base weaves certainly also contributed. Before these new felt types, water was flowing from the paper in the lateral direction of the felt backwards in the machine direction and in a solid press out over the front side of the bottom press roll. Figure 13 shows such a lateral flow press nip. The transversal flow press (Figure 14) was made possible by suitable press clothing. In this press arrangement, water from the paper flows transversally in the Z direction through the felt and is the transported forwards in the machine direction by the incompressible baseweave structure in the felt to a suction box, where the water is removed. This revolutionary development towards more efficient pressing started in the late sixties.

The fabric press

In 1957 the fabric press (Figure 15) was patented by the Swedish Pulp and Paper Research Institute (STFI) in Stockholm. This innovation was based on an incompressible double-layer fabric woven from monofilaments, the socalled 'inner belt', acting as a recipient for transversal water flow through the nip. A considerable further development was the refinement of the felt needling technique to allow feltmakers to include a similar fabric as a base weave in an all-synthetic felt (Figure 16). Sections of such a felt are shown in Figure 17.

Double-sided dewatering

For more energy saving in the dryer section, it now became possible to start pressing already on the couch (Figure 18), removing water from both sides of the sheet, as shown in Figure 19. In addition, later presses could be designed with two felts in the nip for double-sided dewatering.

Improved felt material:

Numerous combinations of components have been created in order to design felts meeting the demands for more efficient pressing. All polymeric commerically available fibre materials did not meet our stringent specifications, which forced us to develop chemical modifications of the material.

To the right in Figure 20 a magnified photo of the surface of a synthetic press felt is shown after a demanding test in Nordiskafilt's experimental press. Ordinary felt fibres are showing two types of defects. Some fibres are flattened and consequently the felt compacts. In addition the fibres fibrillate, which means that the felt loses fragments of fibres and consequently also loses weight. Chemical degradation results in similar damage.

By means of a chemical treatment, the damage can be reduced significantly, as shown to the left in the figure. The fibres are much less flattened and there is hardly any fibrillation.

As one example of many investigations, a chemical degradation test at high temperature is shown in Figure 21. This meant an exposure during 100 hours in aluminium sulphate at pH 3.5 and 80°C. Treated fibres retained 90% of their resistance after 100 hours, while unteated fibres were totally destroyed after 70 hours.

A summary of possible technical advantages of chemical treatments:

- Resistance to chemical attack
- Improved abrasion resistance
- Resistance to compaction
- Resistance to damage from high-pressure showers.
- Improved properties to absorb and dampen vibrations from press rolls.

As an illustration of these advantages, let us now look at two felts (Figure 22). To the left is an untreated felt and to the right a treated one. The photo was taken after operations in Nordiskafilt's experimental press. After this the two felts were conditioned with a high-pressure shower. To the right in Figure 23 we can see that the treated felt is intact, while the untreated one to the left is so badly damaged that the base weave is visible, because the felt lost a considerable amount of fibre fragments.

Wide nip presses

In the Extended Nip Press (ENP) from Beloit, a shoe presses a belt, a felt and the paper against the press roll. This concept has been followed by rather similar designs; the Intensa-S Press from Escher Wyss and the Flexo-Nip from Voith. An extended-nip effect is also reached in large diameter roll (LDR) presses; the High Impact Press from KMW, the High Intensity Press from Overmeccanica and the Tampella long nip press.

In Figure 24 the ENP type, the LDR type and an ordinary press with hard rolls are compared as far as specific pressure (MPa), linear press load (kN/m) and nip length (mm) are concerned. Although the linear load in this example is more than ten times higher for the ENP than for the ordinary press with hard rolls, the specific pressure in the ENP than for the ordinary press with hard rolls, the specific pressure in the ENP is only half of that in an ordinary hard nip. On the other hand the nip length and pressing time are ten times longer. The advantage of long nip presses is the high press impulse, i.e. the product of specific pressure and pressing time, corresponding to the surface below the curves in the figure.

The felt suffers more from the high press impulse in the ENP than from the high specific pressure in an ordinary hard nip. Nordiskafilt's chemical treatment referred to earlier contributes to compaction resistance during the extended press impulse. Many times not even the heaviest base weaves meet the demands of presses with a high press impulse. We therefore laminate two base weaves together, normally one coarser, compaction-resistant base and a fine one. In this way it is possible to combine low water-flow resistance, high water-holding capacity and uniform pressure distribution in a felt-working under these difficult conditions.

Seamed press felts:

Press felts are becoming heavier- as much as 200 g/sq m- and it is often difficult or impossible to install such felts. It therefore became necessary to develop the seamed press felt (Figure 25). It all started in 1982 as a joint venture between Nordiskfilt and a Swedish sack paper mill. With only two presses in a Twinver arrangement this machine could not reach more than a 33% dryness. Above a basis weight of 70 g/sq. m the machine was dryer limited. Press load could not be increased and the only alternative to reach higher production was to use heavier felts. It already took four hours to change felts weighing only about 1000 g/sq. m. The idea with a seamed felt therefore came up and after a period of development the situation described in Figure 26 was established. For one paper grade production was increased by 30 tons per day up to 400 tons, together with an increase in press dryness by 2%, resulting in a dryer section energy saving of 235 GJ/day. Nordiskafilt has sold close on 1000 seamed felts soley from the Halmstad plant (October 1987) and also licensed other felt manufacturers. Seamed felts are not only used for coarse grades like brown papers and pulp. There is a promising development into more sensitive grades such as fine papers, newsprint, tissue, greaseproof and OTC.

Future press type.

We will no doubt see even more efficient presses of more or less revolutionary designs in the future. They will all contribute to additional energy savings. In a new concept by Valmet, called Sym-Press ST (Figure 27), the granite roll of a Tri-Nip press is replaced by a transfer belt, which does not remove any water. Contrary to the Tri-Nip press with a granite roll, the second and third nips in this new concept are flexible and compressible with a different demand on felt design.

At the 1986 conference "New Technologies in Web Consolidation and Drying", which was arranged in Brighton by the Research Association for the Paper and Board Printing and Packaging Industries (PIRA), a review of innovations, already in operation or under development, was presented. It was mentioned that more than 600 steam boxes were in operation in press sections, resulting in about 1% improved dryness per 10°C increased temperature. Today's press felts must tolerate these demanding conditions. Further away from traditional pressing, such innovations as press drying or the Finnish Convac dryer were mentioned.

Newest and most interesting, is impulse drying (Figure 28), developed by the Institute of Paper Chemistry (IPC) in the USA. this new concept was described by Douglas Wahren at a podium discussion organized by Nordiskafilt in September 1986. The principle for impulse drying is simple. Pressing and drying are done in one operation at a dewatering speed 100-1000 times faster than that of conventional drying. Heat transfer during the experiments has been 7-8 MW/sq. m. compared with 50 kW/sq m for a Yankee cylinder. Theoretically, two impulse drying nips could replace 90% of a conventional dryer section. The paper sheet and the felt are passing between two press rolls, of which the one against the paper is very hot, 150-400°C, while the roll against the felt is cold. In this way steam is generated in the nip and displaces water in the paper. Up to 40% of he water is removed in liquid form, which means very large savings of energy otherwise needed for evaporation.

The question of a suitable material for press rolls working at very high and rapidly changing temperatures remains to be answered. We have fibres at our disposal, although not yet commercially, for press felts working under these hot conditions. they should be resistant enough, even if there is a paper break, which brings the felt in direct contact with the hot press roll. When impulse drying becomes a reality, papermakers will no doubt be prepared to pay for felts made from these extremely expensive "exotic" fibre materials, which were originally developed for use in space.

Energy aspects on the dryer section;

Modern paper machines are built for the highest possible productivity and efficiency. This includes minimizing energy consumption. In width we appear to have reached a limit, as investment costs for still wider machines become excessively progressive. Consequently, additional productivity must be achieved through increased machine speed. With the advanced new designs of the forming and press sections, already today the dryer section works at its limit on many fast machines.

Dryer screens opened up new possibilities:

When monofilament dryer screens started to replace dryer felts made of cotton or wool in the early sixties, a new era of more energy-efficient drying started. Development continues of new types of dryer screens and energy-saving auxiliary equipment for the dryer section.

First of all dryer screens made it possible to shut off the steam in the felt drying cylinders, thereby avoiding evaporation of the water twice, first from the paper and then again from the felt. Many times the felt drying cylinders were used for additional paper dyer groups. The high permeability of the dryer screens also made it possible to design new, more efficient types of pocket ventilation equipment. The thin body of a dryer screen led to the draw-free 'single-run' with one single dryer screen covering top as well as bottom cylinder. This simple arrangement has been of enormous importance of the opertion of printing paper machines at much higher speeds than could be used earlier because of sheet flutter, leading to sheet instability, ceases and breaks. This has no doubt also meant energy savings.

Ventilation and heat transfer:

With dryer screens we can influence two processes in the dryer section: heat transfer and ventilation. Both influence drying efficiency. Heat transfer is related to dryer screen tension, the number of contact points between screen and paper against the dryer cylinder, and the contact area. Experiments in Nordiskafilt's laboratories, using an internally heated copper cylinder (Figure 29), show the outgoing paper dryness with five different dryer screens at four different tensions from 2 to 15 kN/m. The lower figure represents the tension normally used in paper machines. With all types of dryer screens, increased tension gives higher outgoing paper dryness.

Screen tension is the dominating parameter, but a ranking of contact area and number of contact points is shown in Figure 30 at four different tensions. For low tensions the contact area is more important than the number of contact points, while for higher tensions the number of contact points is the parameter affecting heat transfer most. One conclusion is that a spiral dryer screen (Figure 31), with very few contact points but with high contact area, is only suitable- from a heat tansfer point of view — in dryer sections operating at low tension. Woven dryer screens have many more contact points and, using our experience from the manufacture of multi-layer forming fabrics, the dryer screen surface can be much improved on, as shown in Figure 32, where the improved fine surface has double the number of contact points compared with a normal surface. Such an improved dryer screen is shown in Figure 33, having ten times as many contact points as a spiral screen.

As far as the ventilation effect is concerned, we know that dryer screens are pumping air in the directions shown in Figure 34. Ventilation can be further improved by different types of pocket ventilation systems, of which one is shown in Figure 35. The moisture profile of the air across the width of a dryer pocket is shown in Figure 36 for a conventional dryer felt and dryer screen with and without a pocket ventilation system. This explains the overdyring of the paper edges, which sometimes can amount to several per cent. With dryer screens the paper moisture profile is much more uniform, which makes it possible to produce a paper with a few per cent higher average moisture content at the reel. This means selling water at the price of paper and reduced energy consumption.

Air pumping and sheet flutter

As indicated earlier, air pumping is not only of advantage. It also causes problems in the form of sheet flutter in the open draws or at the separation of the sheet from the dryer screen in a draw-free operation as shown in Figure 37. The sheet separates from the screen where the screen touches the bottom cylinder. This can cause wrinkles in the paper at the ingoing nip of the following top cylinder.

Normally this air pumping is referred to as a function of dryer screen permeability and paper machine speed (Figure 38). Higher permeability and higher speed results in a higher amount of pumped air. In spite of measures like reduced dryer screen permeability, a soft paper side surface of the screen for good contact with the paper and the use of advanced pocket ventilation systems in order to reduce the blowing problem, the dryer section still remains a bottleneck, holding back the very high paper machine speeds for which modern forming and press sections are designed. In this situation we have to consider the topography of the back side of the dryer screen and its influence on the air-pumping effect, when the screen approaches the bottom cylinder in Figure 37. the diagram in Figure 39 with logarithmic scales, shows the air velocity close to the back side for machine speeds up to 1,400 m/min.

The air velocity was measured at distances up to 100 mm from the dryer screen. figure 40 represents another dryer screen with a different back side. A lower amount of air is being pumped by the back side of this screen.

In Figure 41 we let the computer give us a three-dimensional image of the back side of both screens referred to earlier. At the top of the figure we seen the back side of the screen with the higher air-blowing effect. Although the lengthwise knickles are reaching the highest level in the topography, a clear crosswise orientation is present at a somewhat lower level. At the bottom of the figure the back side of the screen pumping less air is shown. In this case there is almost nothing of crosswise orientation. this back side instead shows a pronounced lengthwise orientation, which explains the reduced air pumping.

Permeability and aerodynamic properties of the screens

The ventilation effect of dryer screen contributes to more efficient drying, but is also a limiting factor. This makes it necessary to each a balance between these positive and negative factors with regard to permeability and aerodynamic charactristics. We must also take into consideration that dryer screens for high-speed machines have to operate with different arrangements of blow boxes for a proper moisture profile, yet still maintain the sheet in a stable condition. Such arrangements were described, for example, by Kokkonen and Lindstrom (3) already at the 1982 Water Removal Symposium in Canada. The development of dryer screens continues in test rigs and wind tunnels for optimum energy consumption and productivity. There is no doubt that newsprint, and perhaps also other printing papers, will be produced at machine speeds exceeding 1,500 m/min relatively soon.

Silent drive

Recently a new term in dryer section vocabulary, 'Silent Drive', was introduced. Actually silence is only one advantageous side effect of this innovation. A high-speed paper machine in Canada was trimmed above the designed speed and the mill experienced frequent dryer gear breakdowns. In order to solve the problem, the unique idea came up to use the screens to drive the cylinders with drive motors connected to the felt rolls. This innovation was made possible by stable monofilament dryer screens and enables machine builders to design identical frames at both sides of the machine. This will no doubt lead to a more symmetric ventilation, and consequently also to energy savings, while previously the gear housing on the drive side created a ventilation disturbance.

References:

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Model mill : Production 500 tons/day

	SEK/ton
Market price	3.300
Variable manufacturing costs	1.700
Total manufacturing costs	2.200
Marginal contribution	1.600

Distribution of variable manufaturing costs

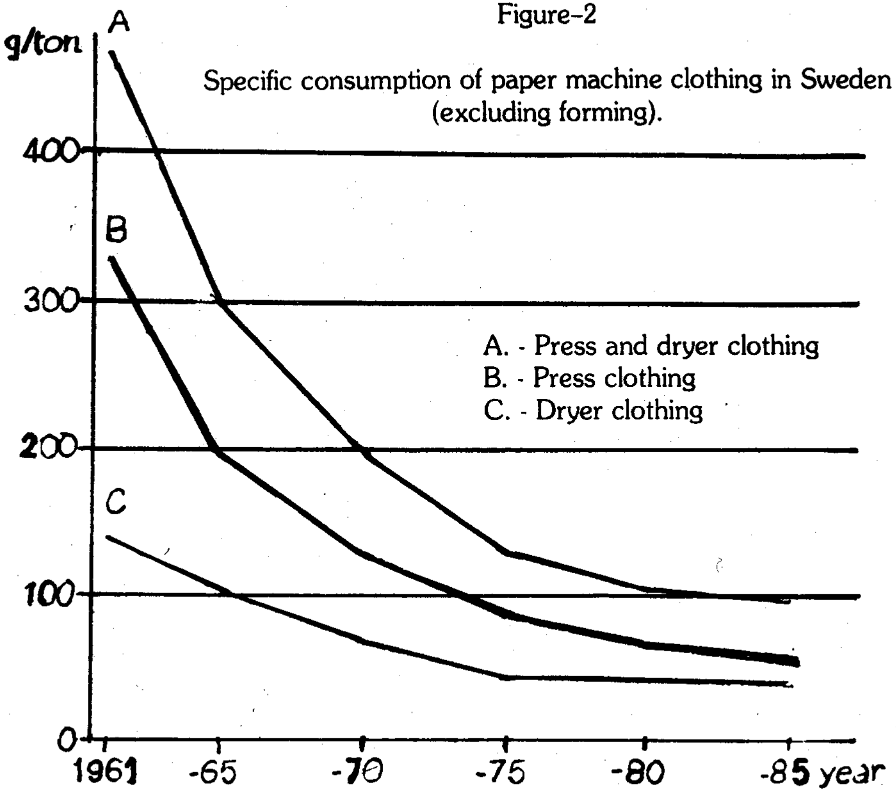
	SEK/ton	%	
TMP	**1.222**	**51.0**	**≈60%**
Cellulose	**183**	**8.0**	
Chemicals	**32**	**1.5**	
Added steam	**164**	**7.3**	**≈10%**
El. energy PM	**68**	**3.1**	
Wrapping material	**52**	**2.4**	
Forming fabrics	**14**	**0.6**	**≈2.2%**
Felts and Dryer screens	**36**	**1.6**	
Other material	**33**	**1.5**	
Variable manufacturing costs	**1.705**	**77.0**	
Personnel	**318**	**14.0**	
Maintenance	**99**	**5.0**	
Other manufacturing costs	**86**	**4.0**	
Total manufacturing costs	**2.209**	**100**	

Figure-1

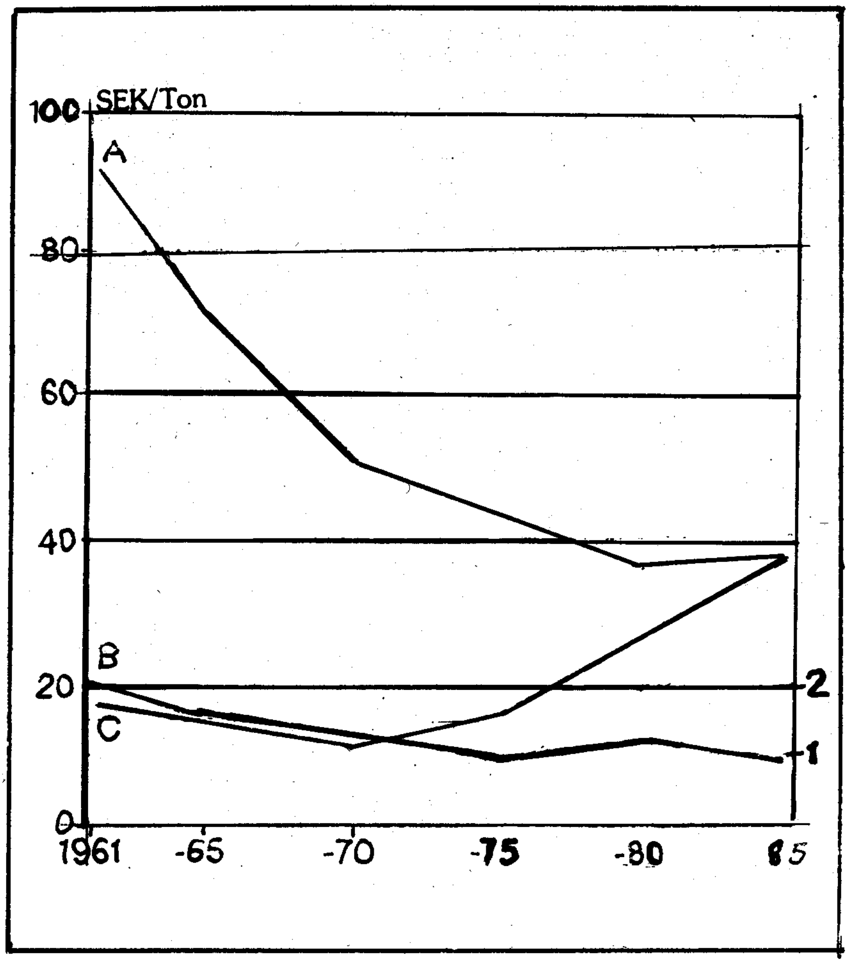
Cost structure at a Scandinavian newsprint mill 1986
(Jaako poyry study).

Figure-2

Specific consumption of paper machine clothing in Sweden (excluding forming).



A. - Money value July 1985
B. - Percentage of the export price of paper and board.
C. - Current money value.



Figure–3

Cost of paper machine clothing in Sweden (excluding forming).

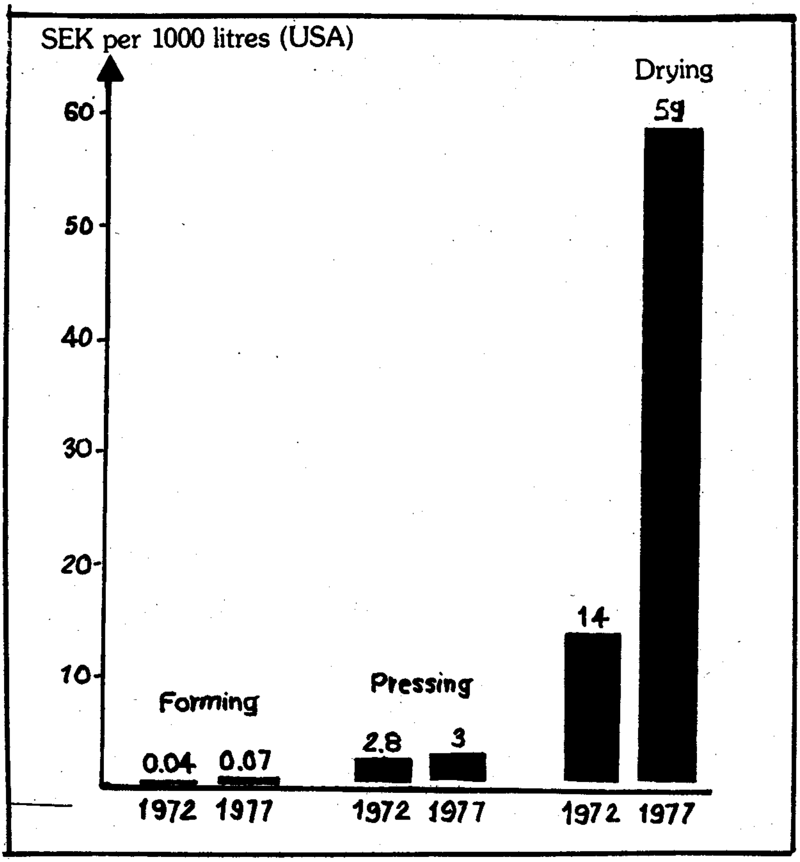


Figure-4

Comparative dewatering costs, 1972 and 1977.

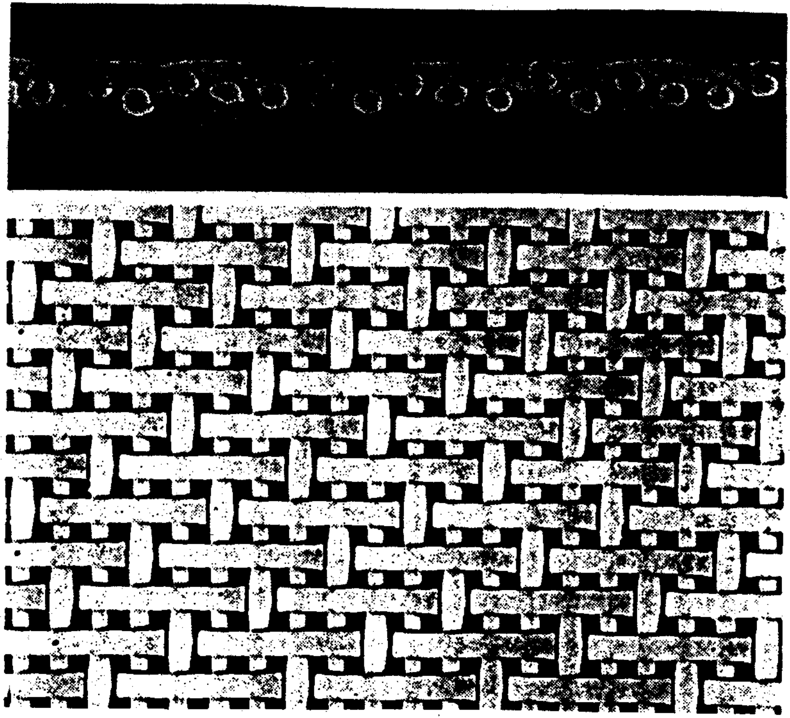


Figure 5
Cross section (MD) and face-view of a MONOTEX K3 single-layer forming fabric.

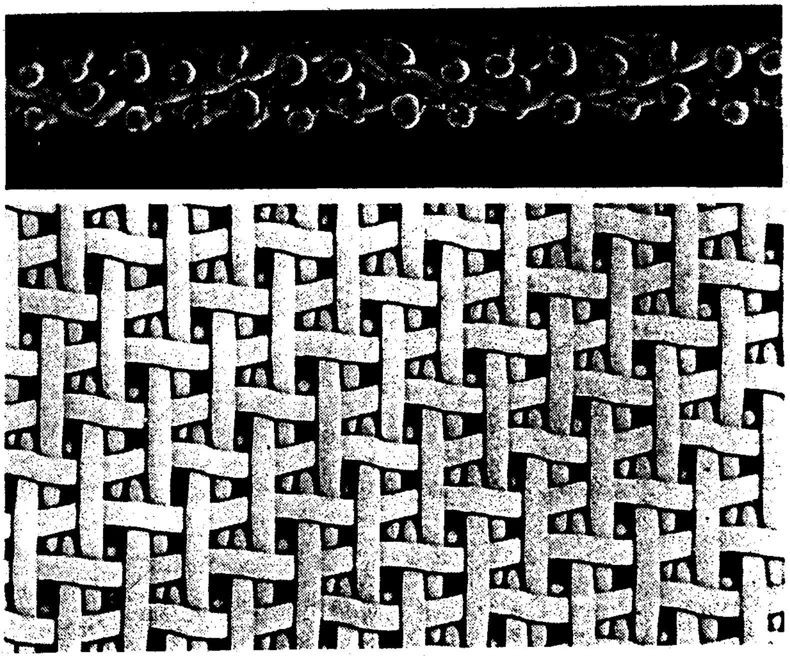


Figure 6
Cross-section (MD) and paper side of a DUOTEX R12 double-layer forming fabric.

	Vacuum kPa						DRAG load kW
Box numbr	1st	2nd	3rd	4th	5th	6th	
Normal situation	14	14	19	21	18	12	397
Same drainge more efficiency	7	10	—	13	20	25	304

Decrease 23%

Figure 7
Effect of applied vaccumsin flat suction boxes on wire section drive load.

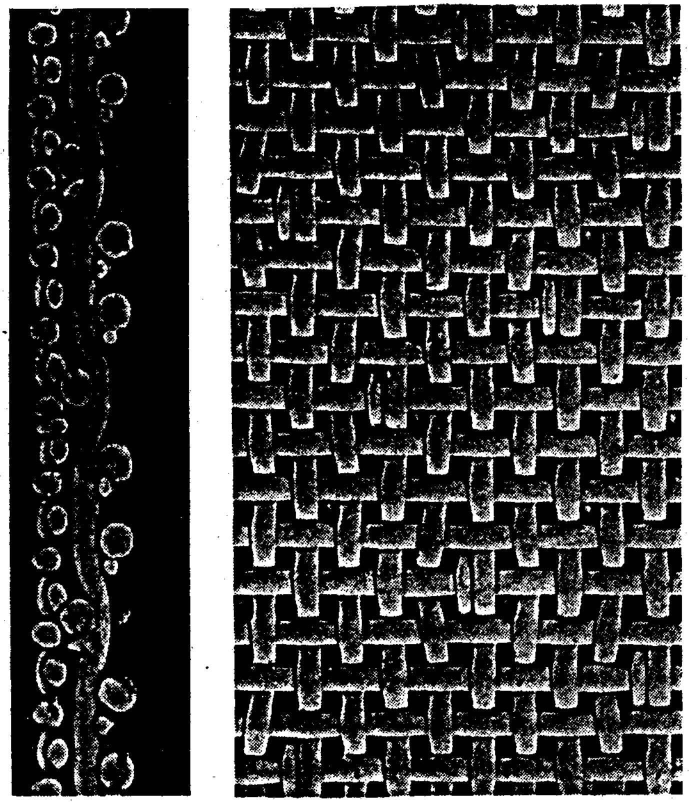


Figure 8
Cross-section (MD) and paper side of a TRIOTEX JC32 triple layer forming fabric.

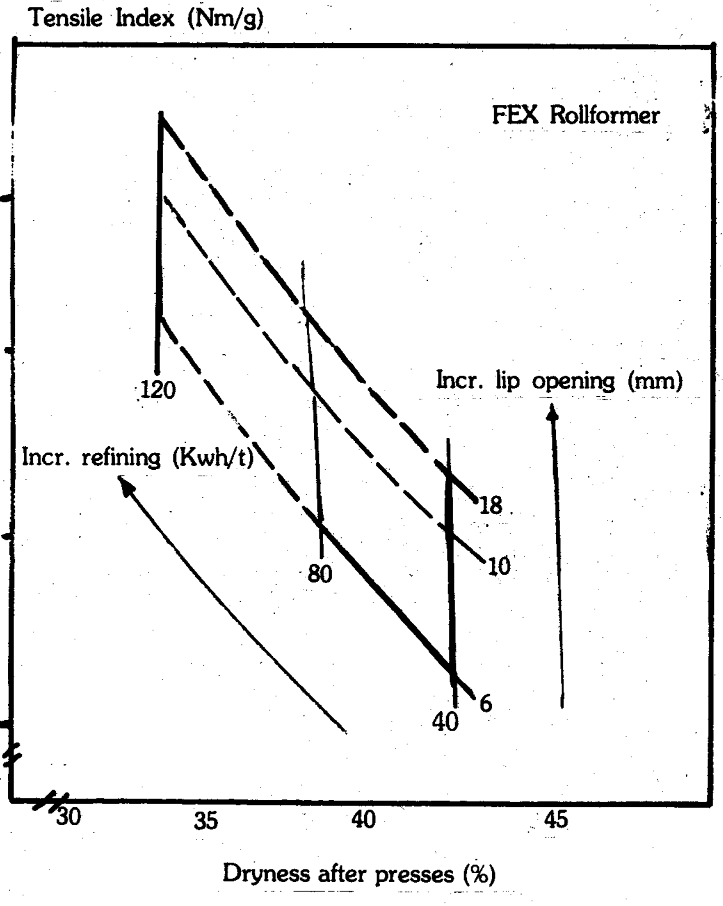
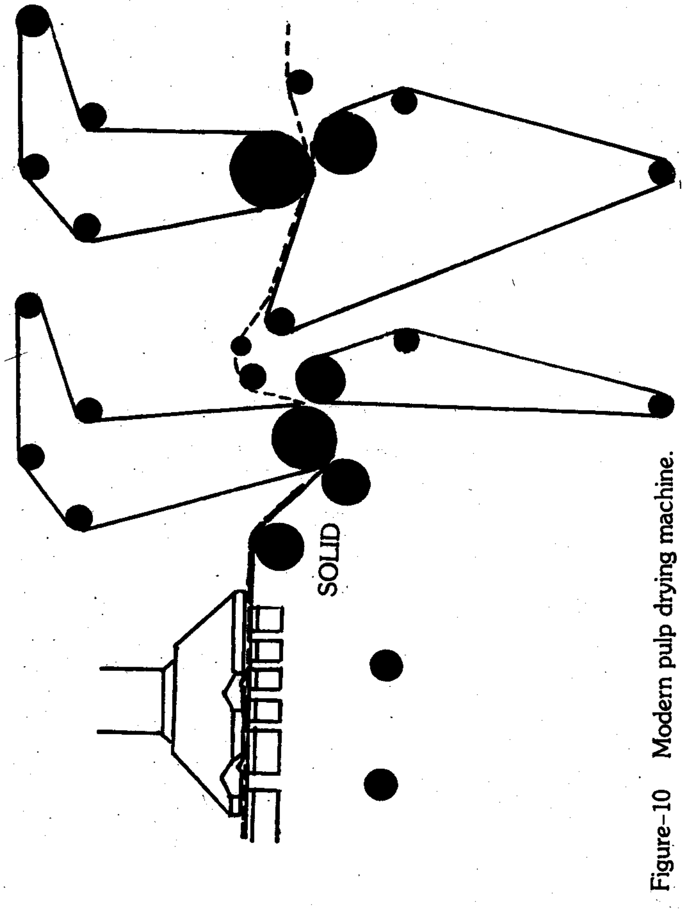


Figure-9 Refining energy v. dilution - influence on tensile index.



Figure–10 Modern pulp drying machine.

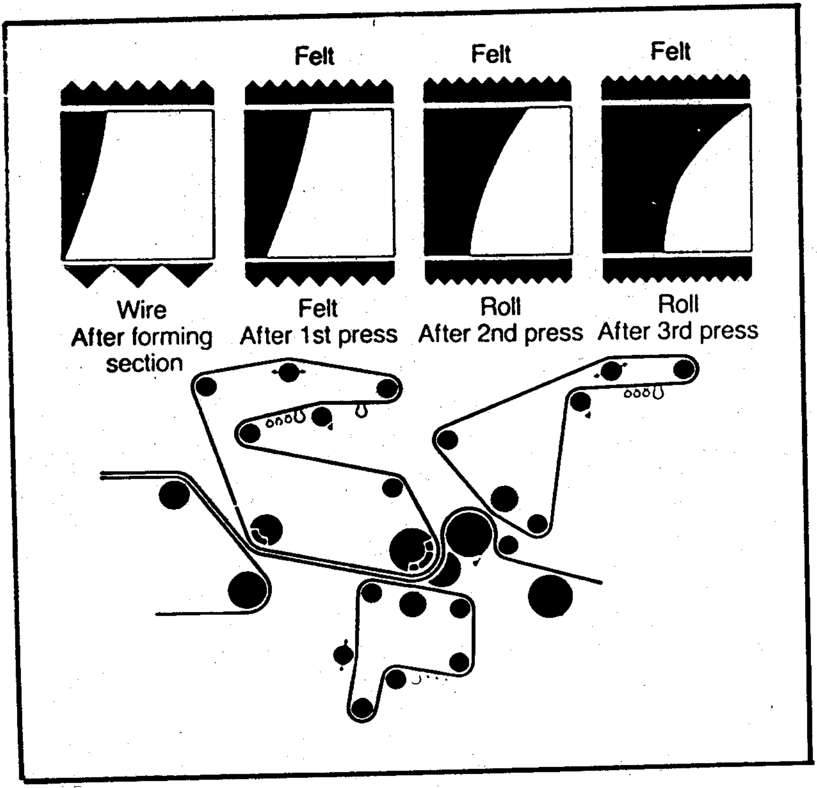


Figure 11

Two-sidedness. Density distribution in Z direction and surface smoothness. Fourdrinier plus Tri-Nip press.

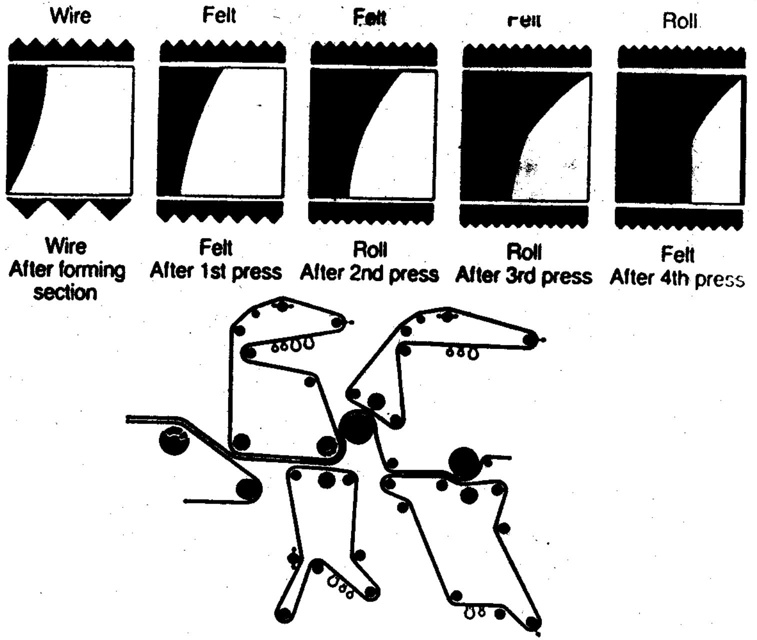


Figure 12 Two-sidedness. Density distribution in Z direction and surface smoothness. Fourdrinier plus Tri-Nip press with separate 4th press.

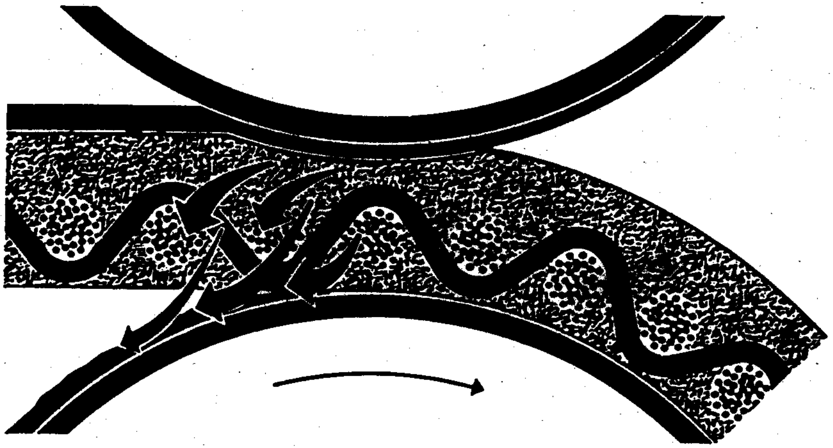


Figure 13
Press nip with lateral flow

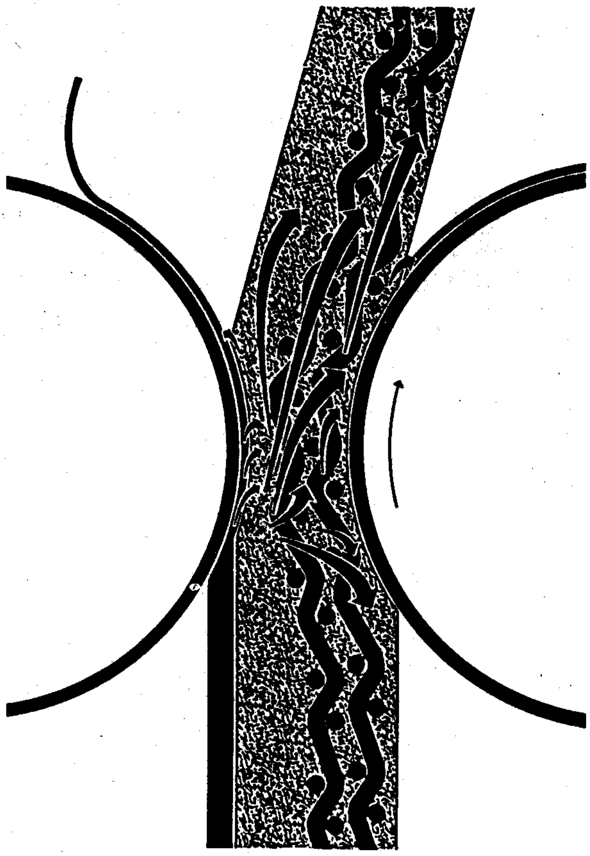


Figure 14
Press Nip with Transversal flow

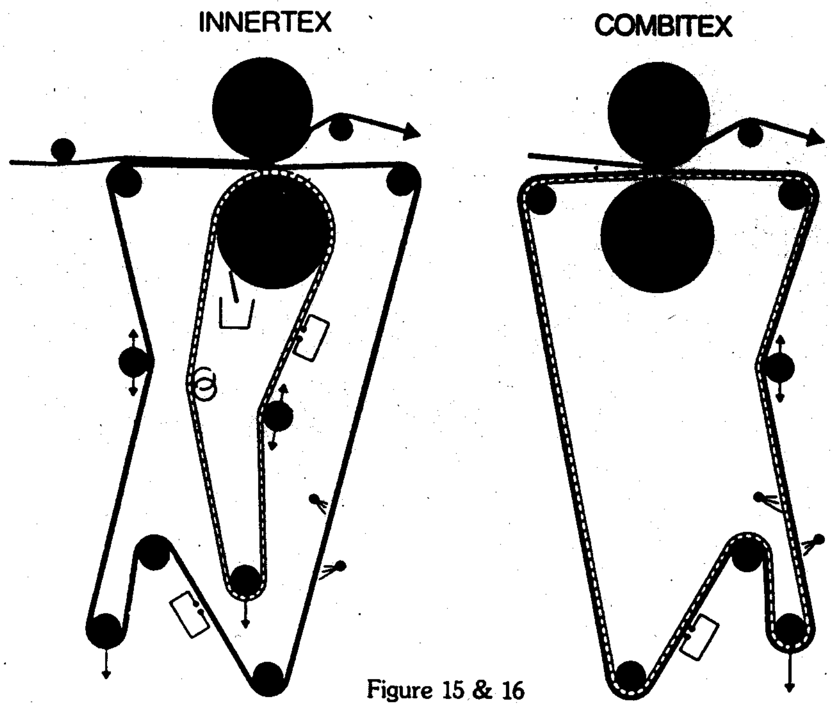


Figure 15 & 16

Fabric press and combination press felt Arrangement

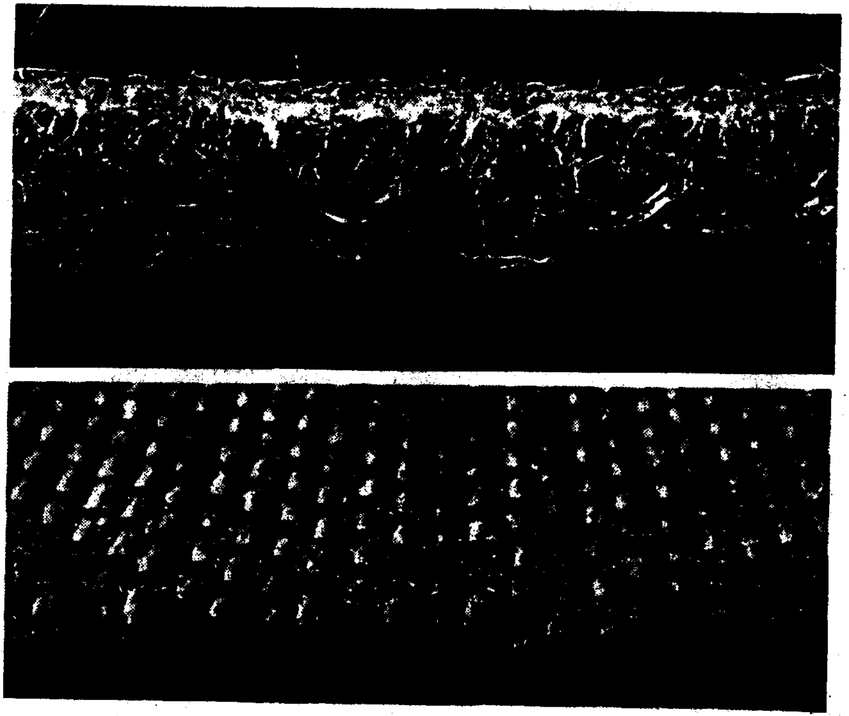


Figure 17 Cross Section (CMD) and baseweave of a combitex press felt.

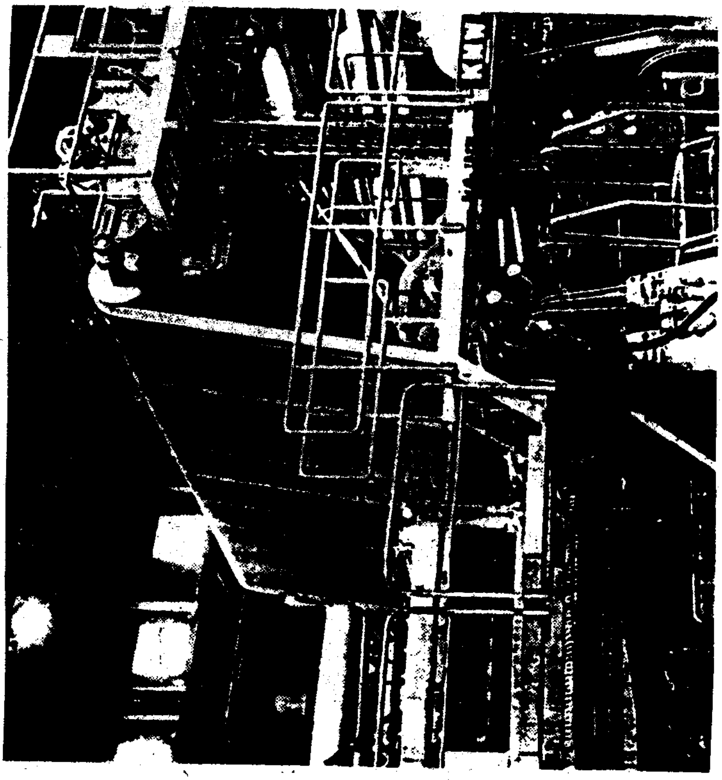


Figure 18 Couch press on a pulp drying machine

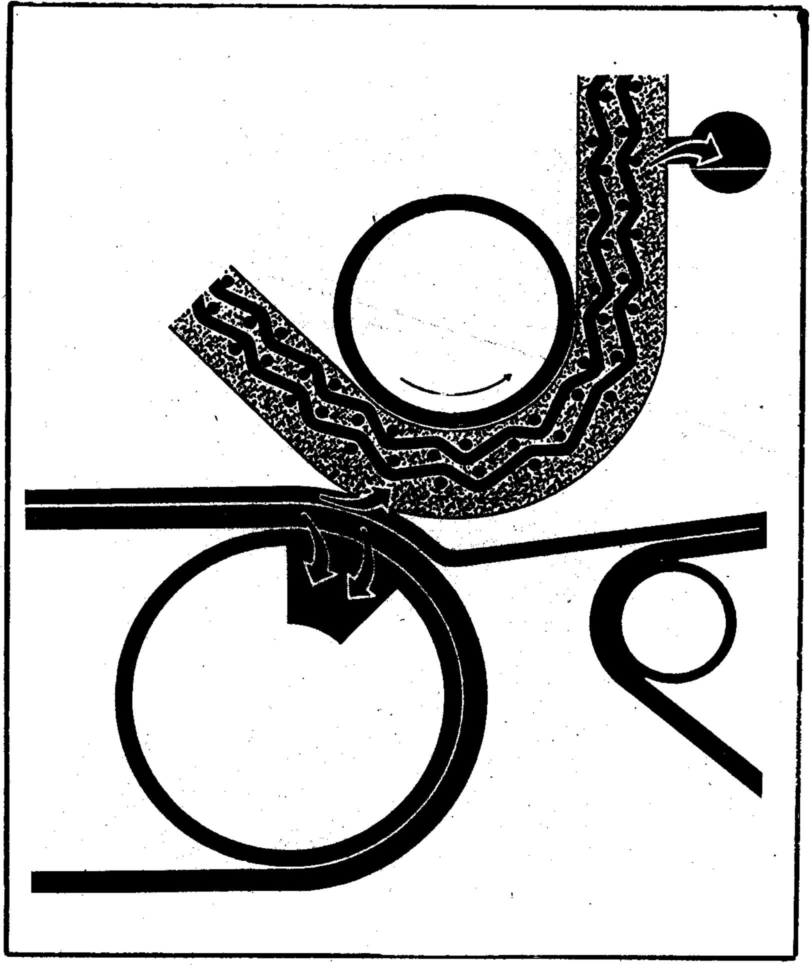
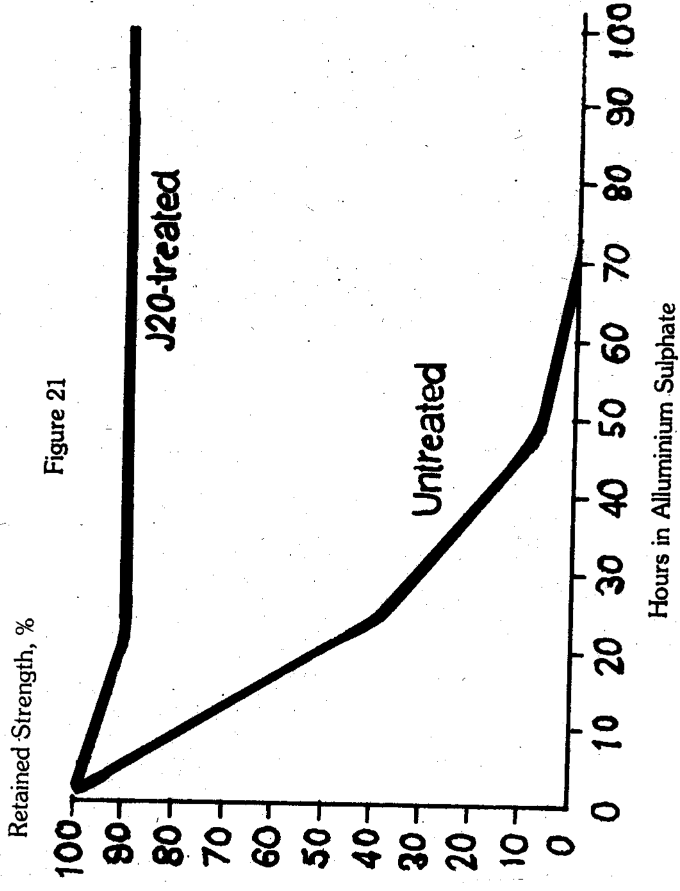


Figure 19
Couch Press arrangement

Figure 20

Chemically treated felts show better resistance to fibre flattening and fibrillation

Figure 21



Degredation in an acid environment of untreated and chemically treated polyamide fibres (pH 3.5, 80ºC).

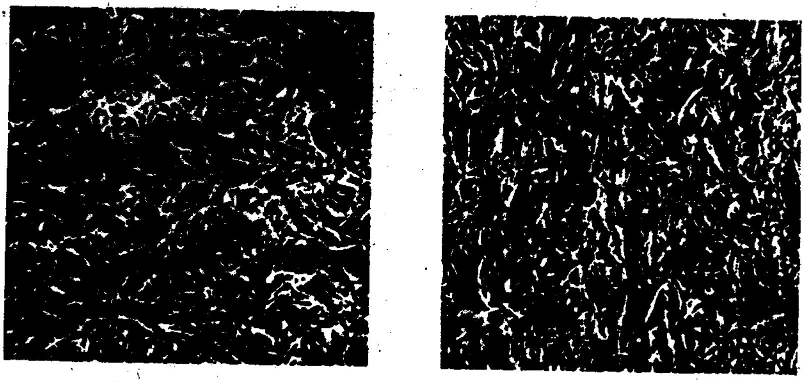


Figure 22

Nordiskafilt's chemical treatment decreases the risk for fibre shedding when using high-pressure showers. The surfaceof a felt is shown after being run in an experimental press, but before high-pressur showering.

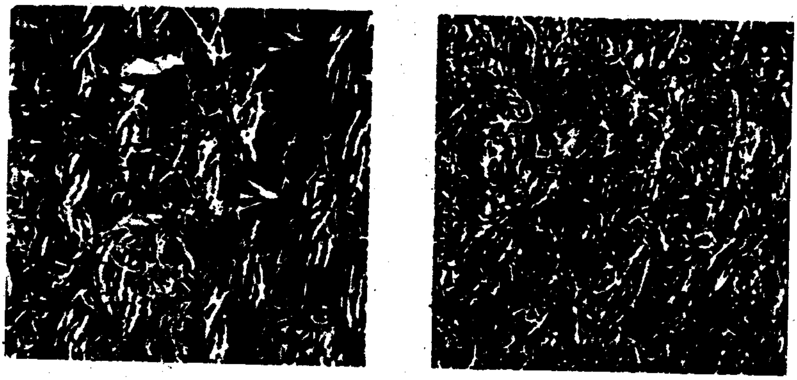


Figure 23

The Surface of a felt is Shown after being run in an experimental press and then exposed ti high-pressure showering.

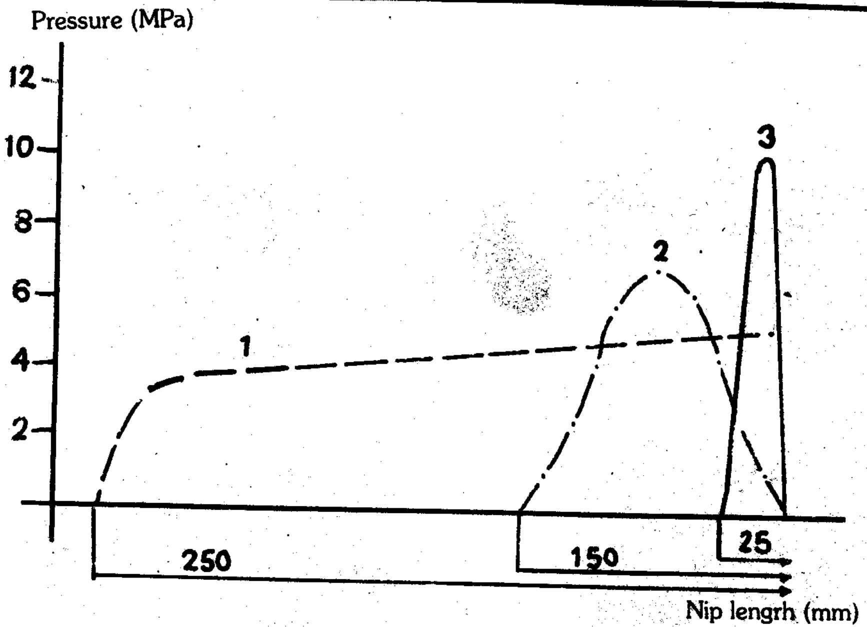


Figure 24 Nip Pressure distributionof different press concepts
1. ENP (1400 kN/m).
2. Large diameter (280 kN/m)
3. Press nip with hard rolls (120 kN/m)

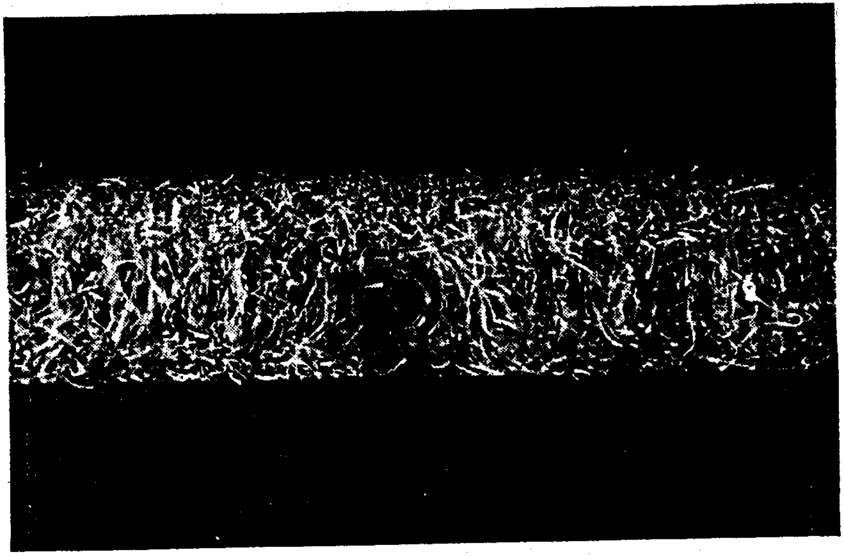


Figure 25

Cross-section of a COMBICRAFT seamed press felt.

	Seamless felt	Seamed felt	Change Change
Speed at 80 g/m^2 (m/min)	600	650	+50
Production (tons/day)	370	400	+30
Dryness after pressing (%)	33	35	+30
Water evaporated (tons/ton paper)	1.79	1.63	—0.16

Heat consumption is 3.7 GJ/ton water evaporated.

Heat saved at a production rate of 400 tons/day is 235 GJ/day

Figure 26

Press performance - comparison of seamless and seamed felts

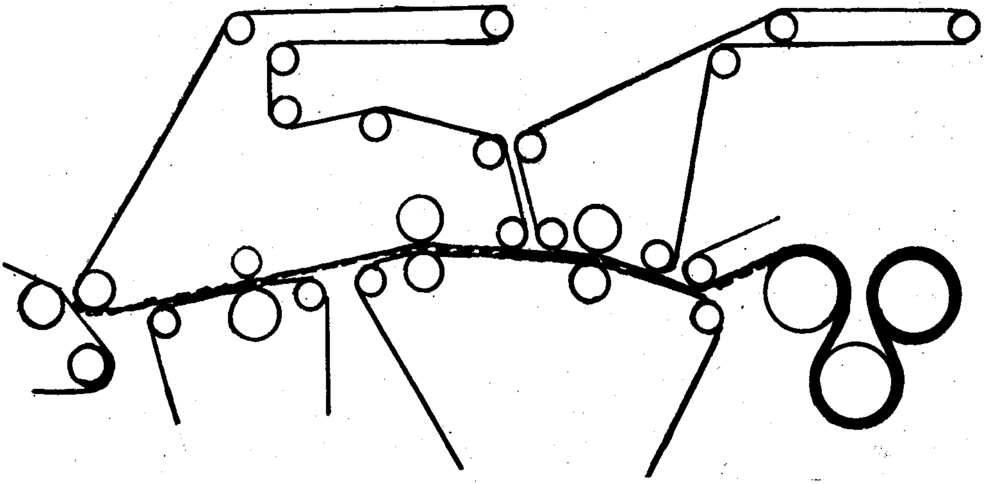


Figure 27

Valmet's Sym-press ST.

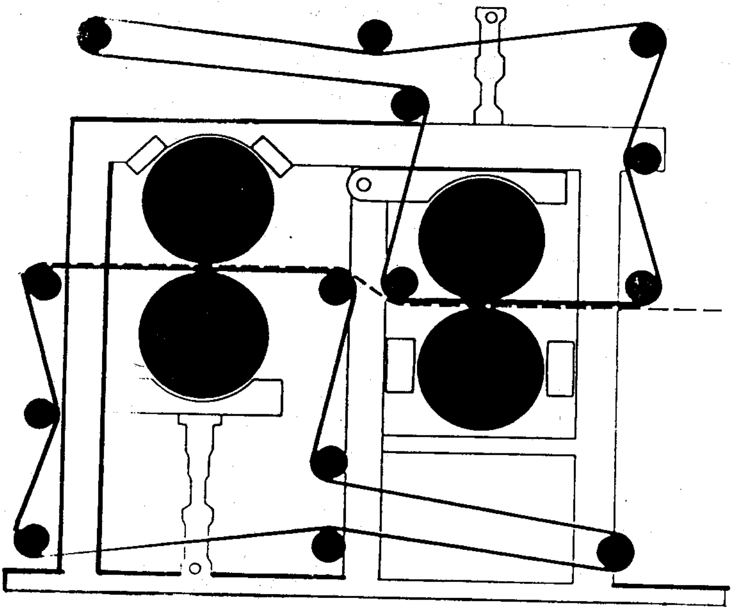


Figure 28

The Impulse Drying concept

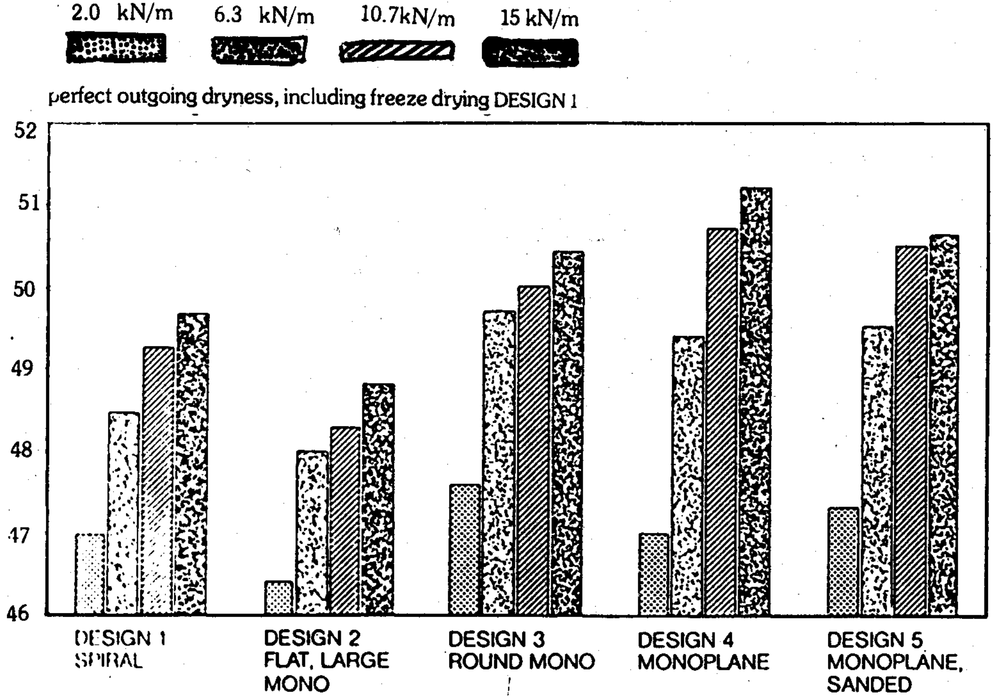


Figure 29 Influence of fabric tension and design on paper drying.
Grammage 40 g/m², ingoing dryness 40%

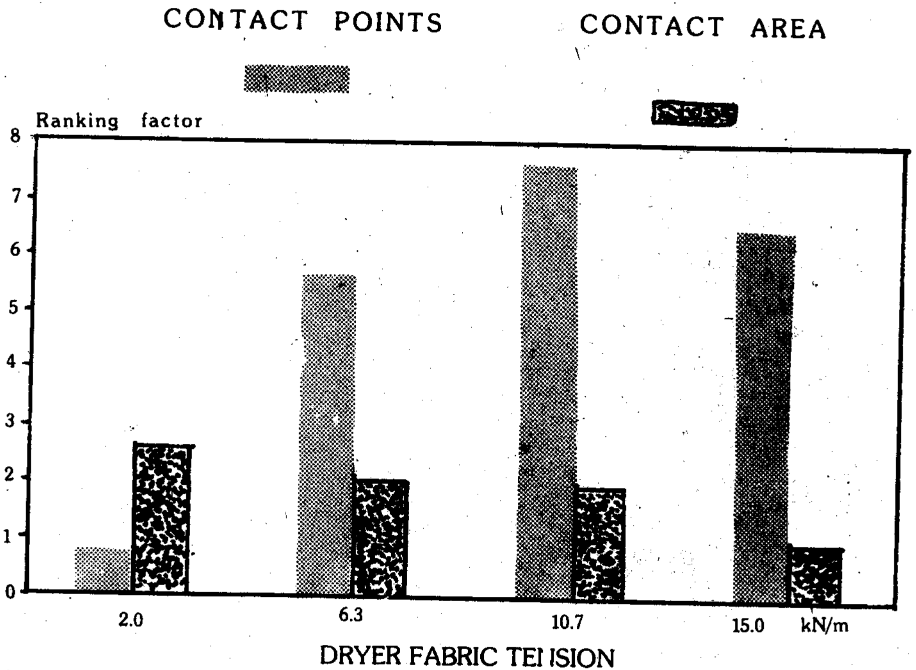


Figure 30 Influence of fabric/paper contact area and number of contact points on the rate of drying at difference fabric tension.

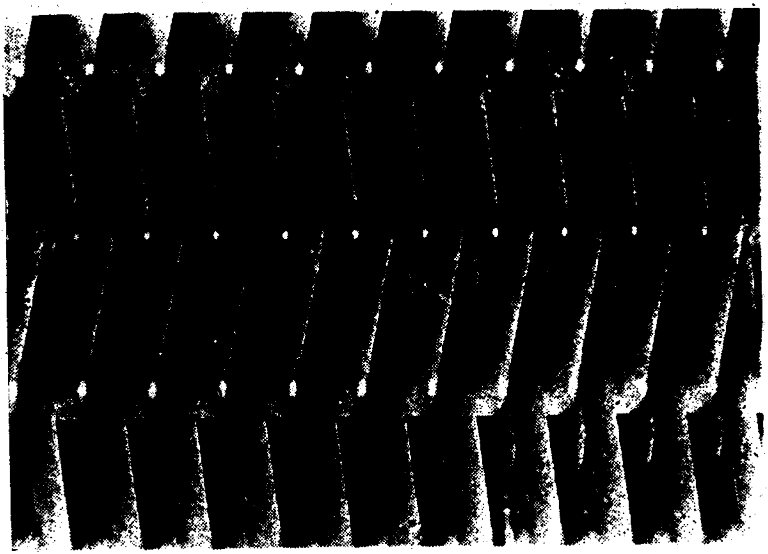
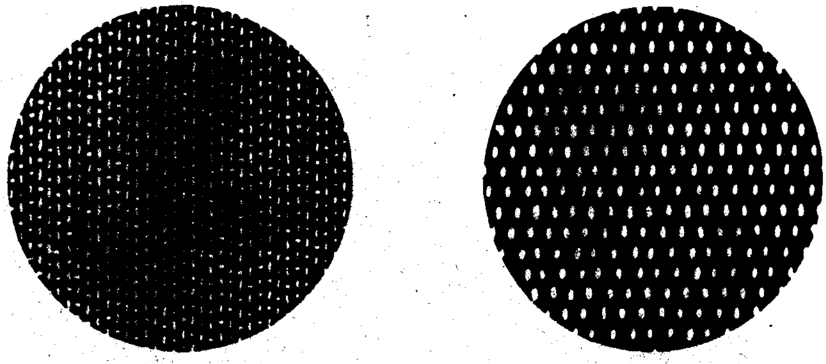


Figure 31

The SPIROTEX Spiral dryer screen.

PERMAPLANE



Fine Surface
90 —110 contact points
per cm²
15% contact area

Normal Surface
30 —50 contact points
per cm²
10% contact area

FIGURE 32 Surface impressions of different dryer screens.

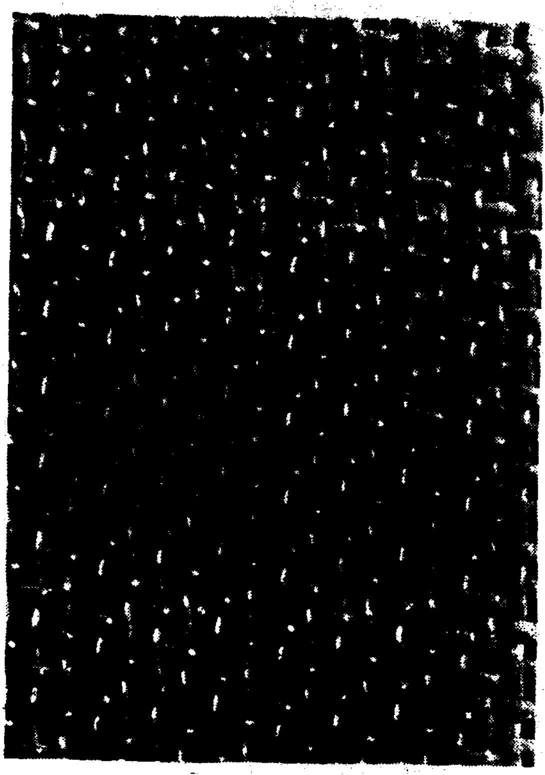


Figure 33 PERMAPLANE dryer screen with a fine surface.

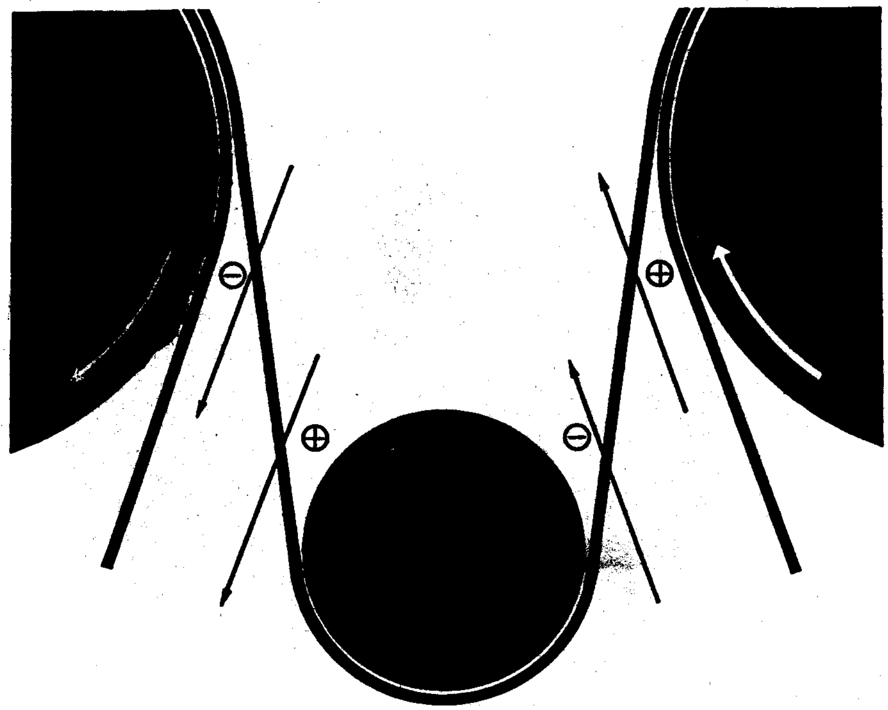


Figure 34 Dryer pocket with a screen

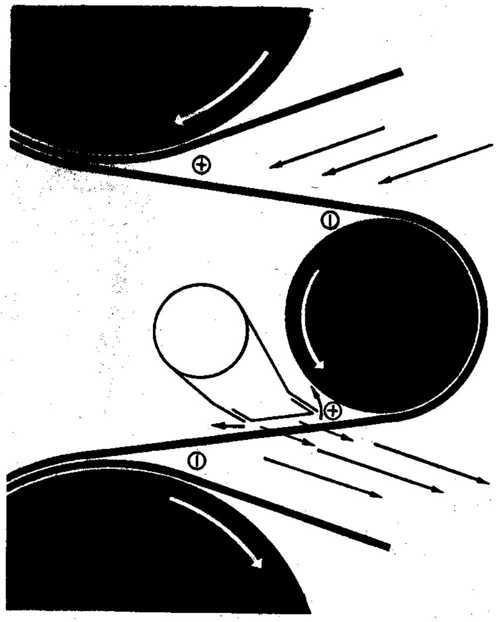


Figure 35 Pocket ventilation according to valmet.

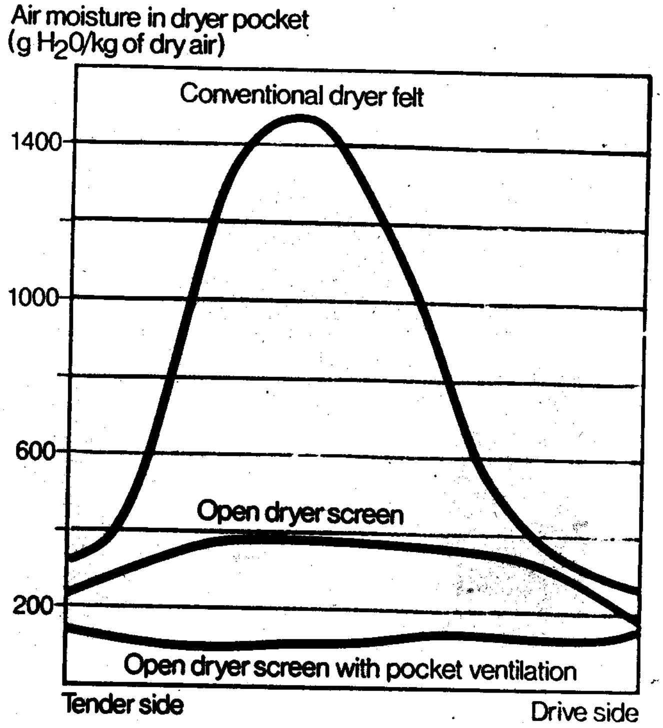


Figure 36 Air moisture profiles across the widthof a dryer pocket.

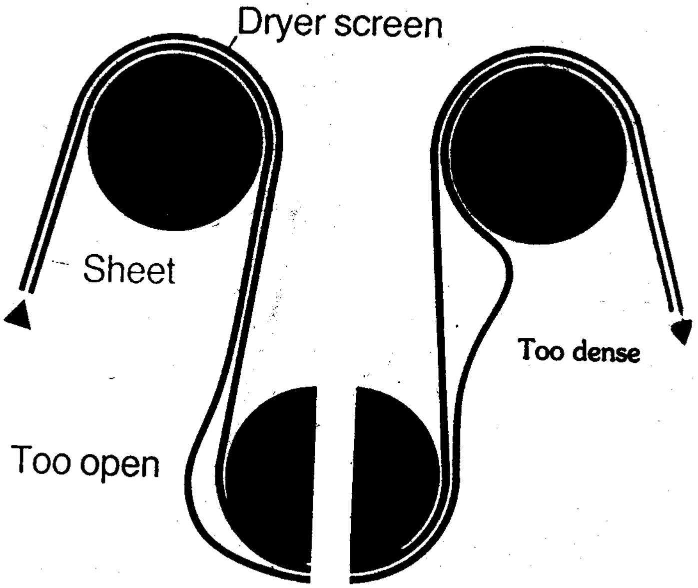
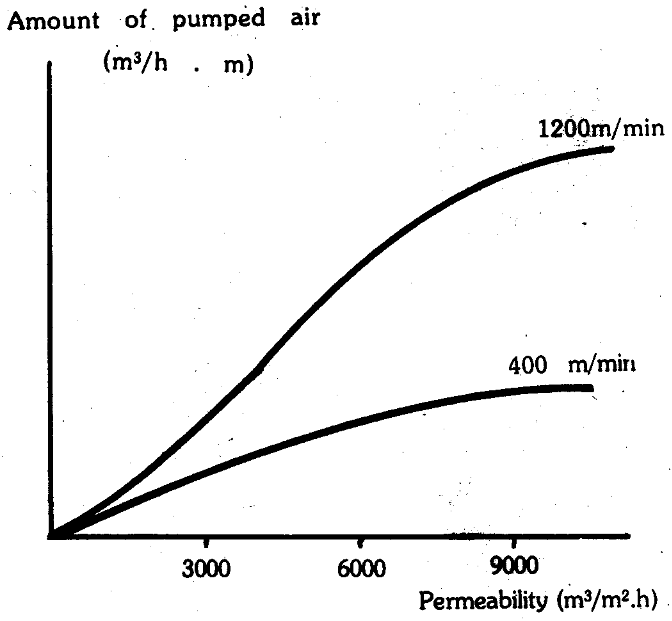


Figure 37 Sheet run problems with draw-free arrangement.



Figure–38

Influence, of dryer screen permeability and machine speed on air

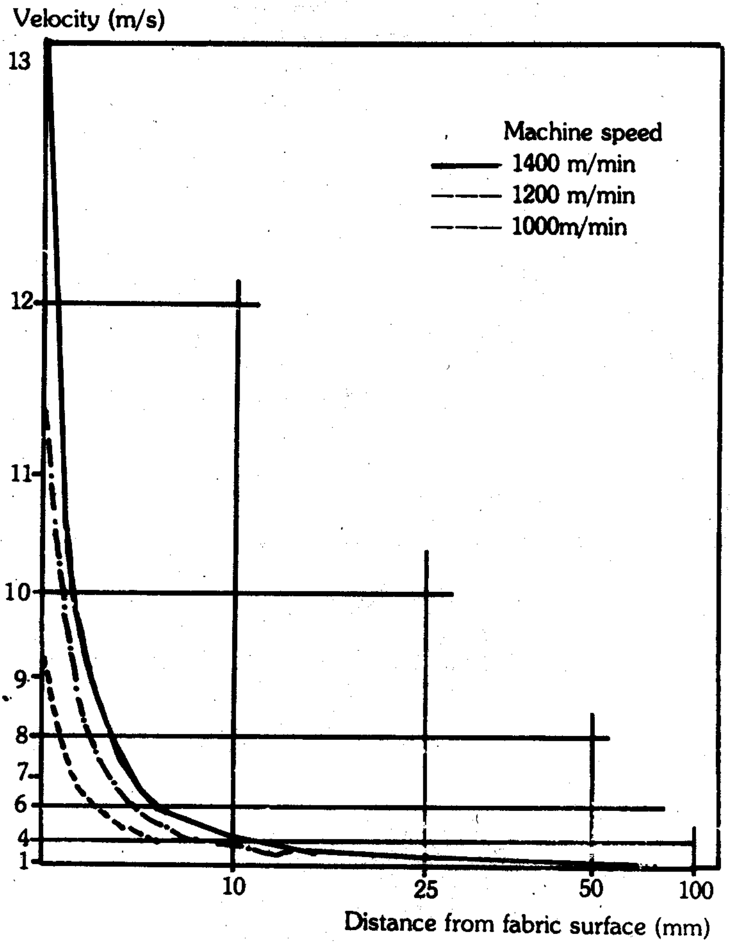


Figure-39 Air pumping on the back side of a dryer screen.

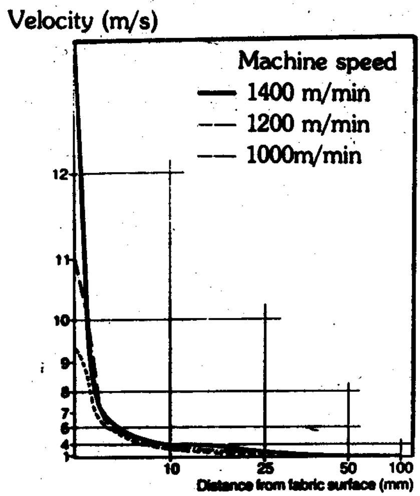
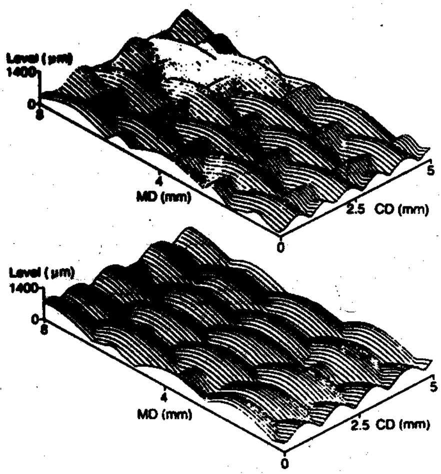


Figure 40–

Air pumping on the back side of a dryer screen different from that shown in Figure 39.



Figure–41 Computer images of the back sides of screens.