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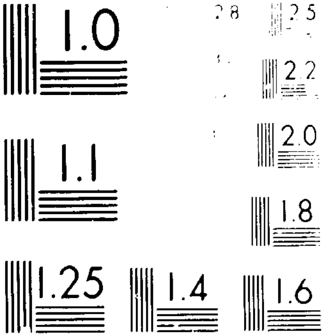
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USE OF BAGASSE AND OTHER UNCONVENTIONAL RAW MATERIALS IN MODERN PAPER MAKING AND EXPERIENCES OF THE NEW FORMERS FOR ABOVE *

by

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General

Strongly growing paper industry throughout the world decreases the world wood resources to an alarming degree and therefore, today, we turn more and more to the use of non-wood fibres and other fibre resources which are not traditionally used as raw material in paper making. This imposes an interesting challenge to the development of special pulping technology and equipment industry in order to produce a competitive fibre material of these non-traditional materials. Several methods for solving these problems have been developed and also the practical results in many cases are very promising today. This challenge is, however, as important also from the paper machine manufacturer's point of view, because many problems have to be solved in the design of the paper machine, because the special properties of the new fibres have to be taken into account.

Most research has been concentrated on the wet end of the paper machine: the headbox, the former and the press. This is where the paper web is formed and compressed, to be later dried and calendered by processes which are more or less standard to almost all types of fibres.

When looking at the suitability of a wet end concept to transformation of a given type of fibre suspension into a sheet of paper, one must study the subprocesses occuring in the various areas of the machine and their effect on the formation of the fibre web. This makes it easier to isolate those aspects of the process which must be modified to obtain a given quality of paper from a certain type of fibre.

Various paper machine manufacturers produce an apparently wide scope of wet end designs. Yet upon closer inspection these can be reduced to a few basic types. Also the goal of the development program at Valmet Oy has been to create a family of paper machine concepts suitable to the widest range of fibres.
With this presentation I will briefly describe you our machine concepts and their applications to the fabrication of printing papers from various fibres.
The conclusions are based on results from basic research followed by test runs on pilot and full scale plants.

THE EVOLUTION OF FORMING DEVICES

Sheet formation on a paper machine began during the last century, when Fourdrinier developed the flat wire sheet former, a device which has proved itself most flexible and reliable. Improvements gradually appeared, in the form of grooved table rolls and deflectors, small diameter table rolls, foils, wet suction boxes and vacuum foils. Today the fourdrinier still maintains its position regarding speed and quality in paper manufacture. Other methods of web formation were conceived during the thirties, but it took the sixties to get the first operative realisation.

One of the first developments was the Inverform, which was followed by many variations such as the Twinverform, and this formed the basis for the development of the various Bel-Baie formers. Before this Vertiforma design was brought into production and Papriformers followed with somewhat simpler design. The next concept was the Duoformer. Tampella invited its Arcuforma. Valmet began to develop formers at a later stage, and this had the advantage that the good and bad points of former operation were known by then. As a result Valmet could develop the next generation of formers, the Sym-Formers, which have produced excellent results.

A slightly simplified model, the Speed-Former, has been developed for the high speed fabrication of standard newsprint.

Tissue machines were also born with the fourdrinier. The improvement of certain machine components followed, until twin wire former configurations were finally achieved.

The development of board machines followed the same path, though the problems of twin wire formers had to be studied at an earlier stage to produce multiply grades. Tampella e.g. has made a specialty of board formers.

VALMET SYM-CONCEPT PAPER MACHINE WET END

Sym-Concept is a word used to describe our technology for the wet end of a paper machine, i.e. headbox, wire and press section which give possibility to manufacture paper with symmetric properties, i.e. having low two-sidedness and symmetric structure. Basically there are two main versions

1 Sym-Concept with Sym-Former (Figure 1)

2 Sym-Concept with Speed-Former (Figure 2)

SYM-CONCEPT WITH SYM-FORMER

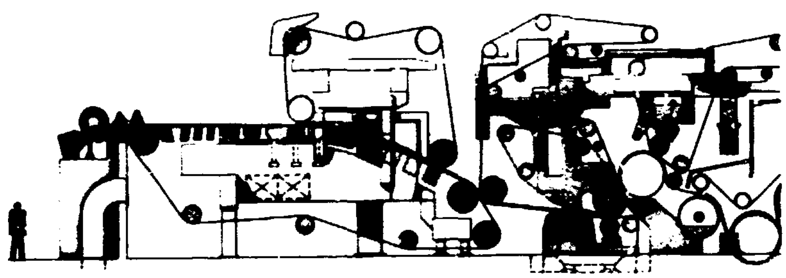

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Figure 1

SYM-CONCEPT WITH SPEED-FORMER

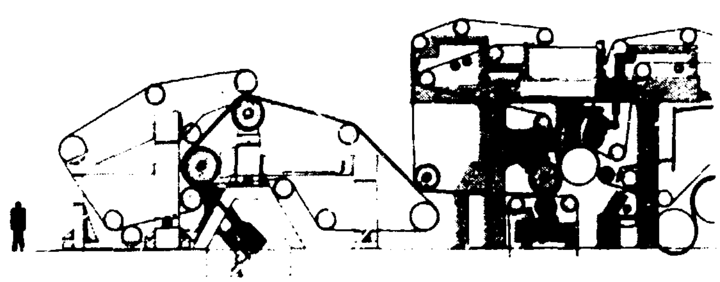

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Figure 2

Headbox

The key elements of our Sym-Nozzle headbox both in the Sym and Speed-Former applications are the same with the exception of the equalizing chamber (Figure 3 and 4).

Sym-Nozzle consists of the following main parts:

- inlet header
- tube bunch
- equalizing chamber (not in Speed-Former)
- baffle plate
- vane section
- slice

When Sym-Former and Speed-Former were developed, it was found that on a Sym-Former a dampening chamber on the headbox was required to dampen effectively the pulsations coming from the approach piping. On the other hand that was not necessary for the Speed-Former, because the pressure variations cannot strengthen themselves on a gap-type former as they do on a fourdrinier table. The gap of the Speed-Former "freezes" the development of pressure variations.

The dampening chamber of Sym-Nozzle used with Sym-Former is located as close to the slice section as possible. This has been done to ensure that pulsations caused by the inlet header recirculation will also be dampened.

SYM-NOZZLE

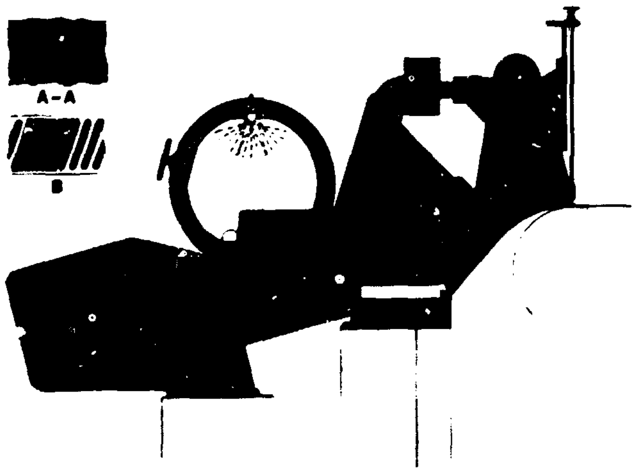

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Figure 3

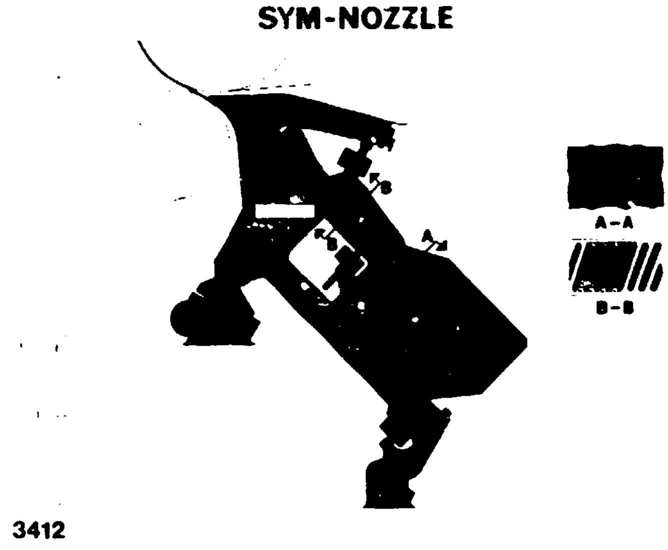

Figure 4

Figure 5 shows the dampening capability (dB) of the Sym-Nozzle attenuator as a function of pulsation frequencies.

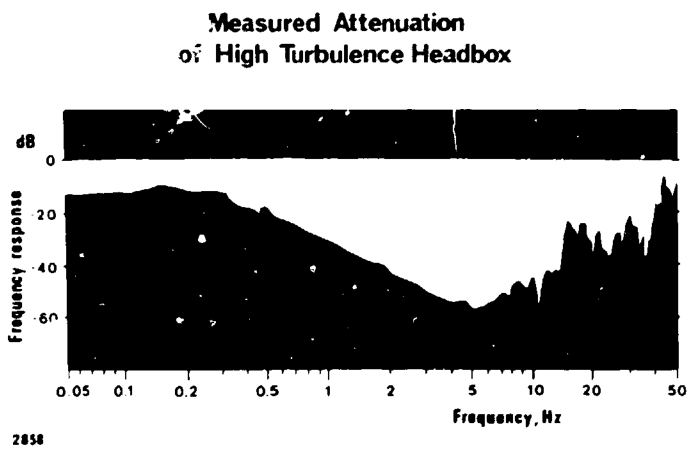

Figure 5

Sym-Former

We have basically three different Sym-Formers, namely Sym-Former F (Figure 6), Sym-Former N (Figure 7) and our latest version Sym-Former SF (Figure 8).

SYM-FORMER F

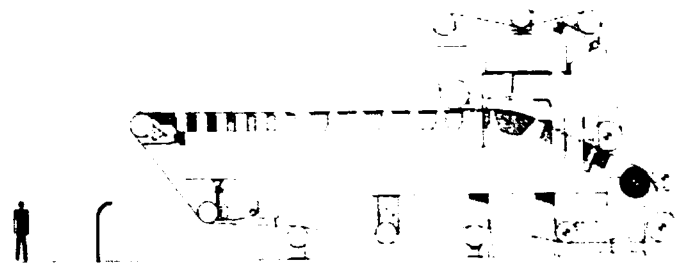

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Figure 6

SYM-FORMER N

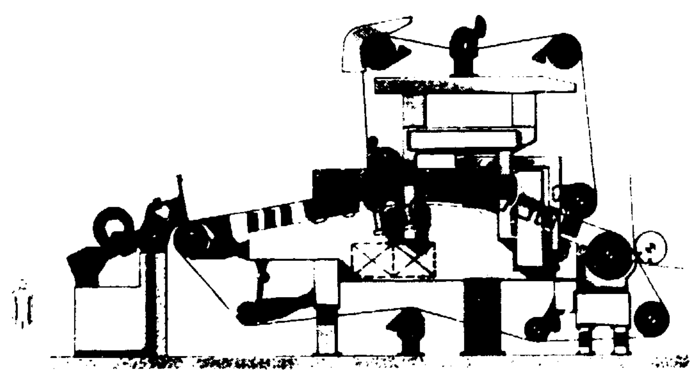

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Figure 7

SYM-FORMER SF

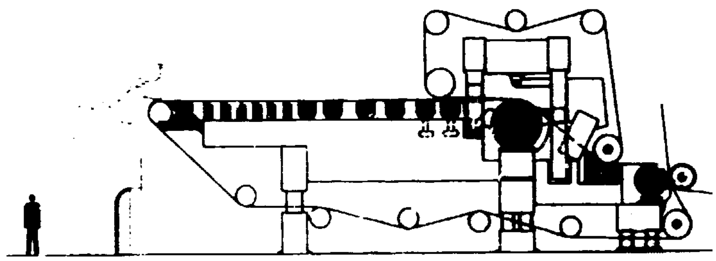

Figure 8

Sym-Former F is recommended for fine paper grades for higher quality purposes and Sym-Former N for light weight newsprint and similar grades requiring more speed potential which is achieved by the uphill dewatering zone and longer forming shoe section.

Sym-Former SF has been developed for manufacturing of high filler content grades and gives a very long wire life and the energy savings compared with the standard Sym-Former are 25 %. With this solution a fairly even ash distribution with the minimum wire wear will be achieved.

Speed-Former

Speed-Former (Figure 9) wire section is recommended only for standard newsprint, (one grade) production on high operating speeds. Speed-Former was developed mainly with high speeds and low operating costs in mind. Due to the rotating dewatering elements the wire life is very long.

Speed-Former T (Figure 10) for tissue was introduced shortly after the newsprint versions. Speed-Former T can have a forming board. The breast roll is solid and thus dewatering takes place in one direction all the time. We have today two of these formers running and making good quality tissue.

SPEED-FORMER

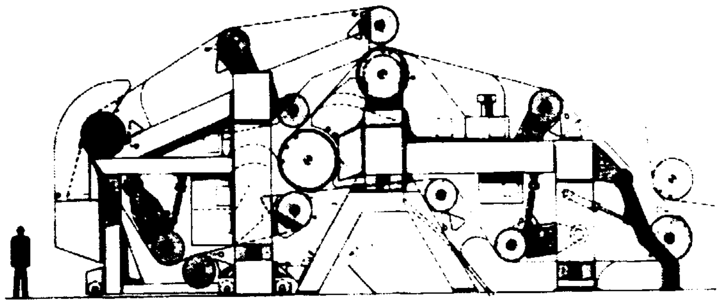

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Figure 9

SPEED-FORMER T

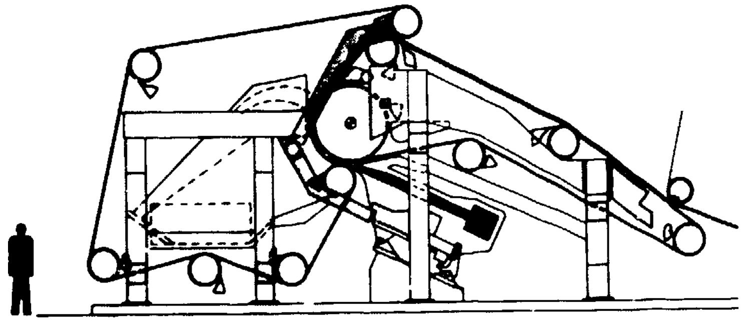

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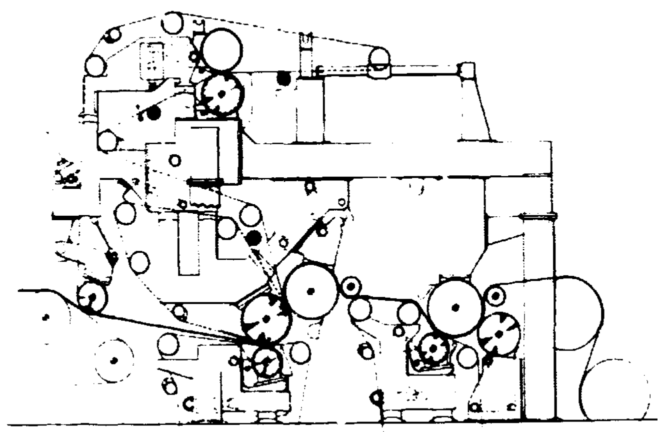
Figure 10

Sym-Press Family

"The mother" of all Sym-Presses is Sym-Press I (Figure 11). This press section has the unique feature that the dewatering is symmetric throughout the press section. From a paper property standpoint this is good but there is one drawback - the first open draw is after the second nip causing breaks when running with high speeds.

SYM-PRESS I



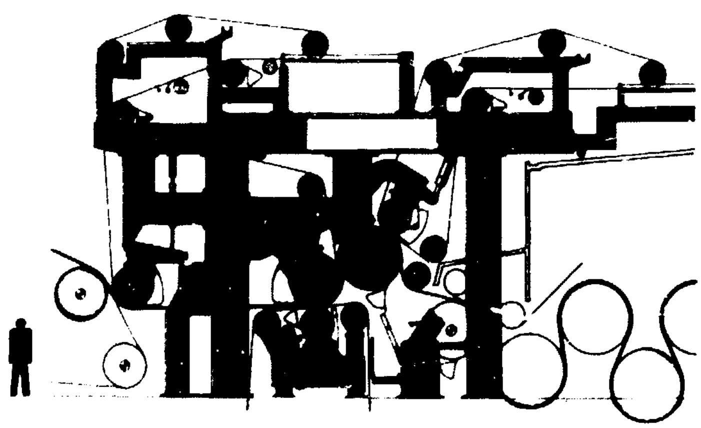
1401

Figure 11

That was the reason why it was developed further into Sym-Press II (Figure 12), where the sheet run is completely closed. Today we could say that the Sym-Press II is used for almost all paper grades due to its

- operation reliability and
- high efficiency.

SYM-PRESS II



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The Sym-Press III (Figure 13) was developed especially for weak furnishes, where the dewatering characteristics of the stock are difficult, e.g. bagasse. This press has four nips to guarantee high enough dryness after the press section.

SYM-PRESS III

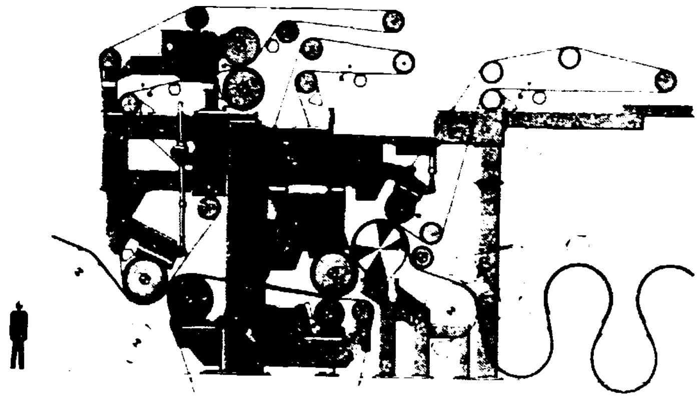

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Figure 13

The Sym-Press T (Figure 14) is specially designed for tissue grades and is successfully running in two mills.

SYM-PRESS T

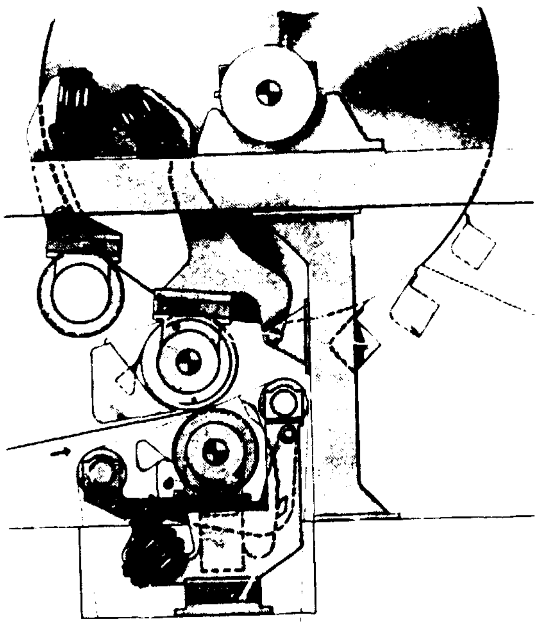

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Figure 14

SUMMARY OF SYM-CONCEPT PAPER TECHNOLOGICAL ADVANTAGES

Sym-Nozzle headbox

The microturbulence created in the Sym-Nozzle headbox contributes to the high initial wet web strength after the press section and to good direction of the finished paper strength properties. The good initial wet web strength improves the paper machine runnability.

Figure 15 shows the effect of headbox microturbulence on the strength characteristics of the wet web. The bottom curve shows the wet web strength of a conventional fourdrinier wet end with rectifier roll headbox and the top curve the wet web strength of the same machine with Sym-Nozzle headbox.

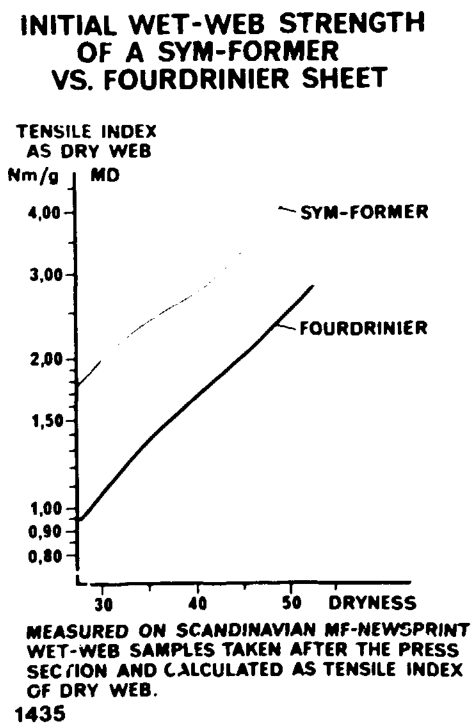

Figure 15

The uniform flow from the headbox slice enables an even basis weight profile to be produced. Figure 16 shows the jet thickness profiles after the forming board for an old type rectifier roll headbox and for Sym-Nozzle.

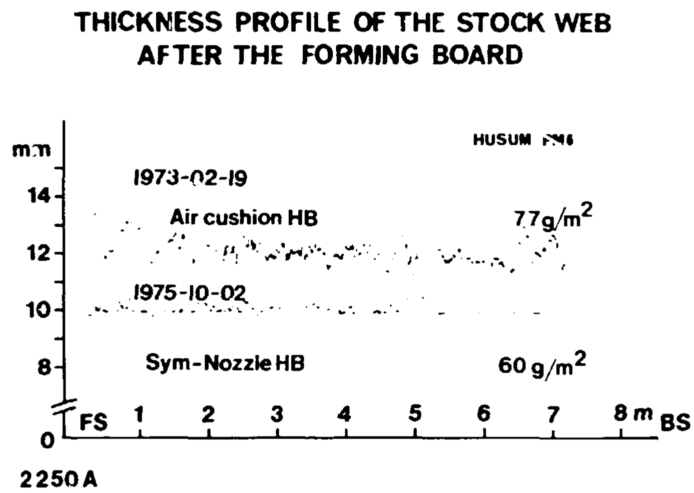

Figure 16

Sym-Former

Figure 17 shows a typical dewatering distribution for a Sym-Former F. It is interesting to see that the water amounts removed on the forming board and by the forming shoes are about the same. This results in the low curl tendency which is typical of Sym-Former paper (Figure 18).

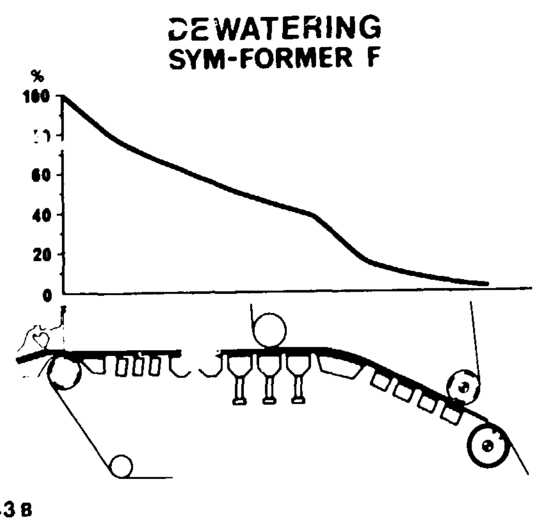

Figure 17

PAPER CURL PROPERTIES
SYM-FORMER VS. FOURDRINIER

	CURL [mm]*	LAST DRYER SECTION TOP AND BOTTOM PRESSURE DIFFERENCE
SYM-FORMER	0...1	0
FOURDRINIER	1...15	100 kPa

*MEASURED FROM A 10 cm DIAMETER DRIED PAPER DISK AS THE DEVIATION OF THE DISK EDGE FROM A PLANE

4969

Figure 18

In addition, gentle adjustable downwards dewatering followed by water removal upwards assures an even ash distribution, which results in an even ink absorbtion on both sides of Sym-Former paper. Figure 19 shows a typical example of fines distribution curves of newsprint manufactured on different formers. Also typical to Sym-Former is a retention close to that of a fourdrinier although the paper manufactured on it has minimum of linting tendency.

EXAMPLES OF
DISTRIBUTION OF FINES

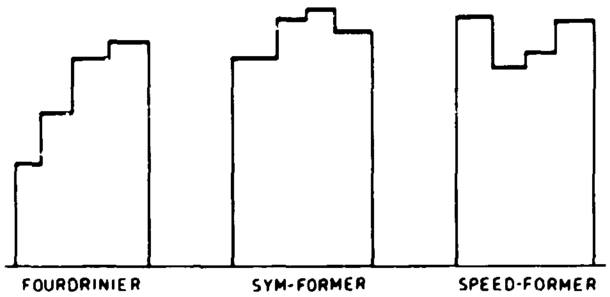

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Figure 19

The exact balance of paper properties is influenced by the operation way of the forming section and design and operation of press part as well as by the types of wires, fabrics and felts.

Wet web strength with different formers

By measuring the wet web strength at the press exit of various types of formers using the same stock and the same basis weight (Scandinavian newsprint, 52 g/m^2), one can arrive at relative wet strength values, using a fourdrinier machine as baseline for the various formers (Figure 20). These values indicate that both stationary and rotary gap formers usually give wet strength values approximately equal to a fourdrinier machine, while a Speed-Former will produce an improvement in wet strength of about 30 % and a Sym-Former of about 58 % over a fourdrinier section. On the basis of our research, these dramatic improvements in wet strength result from the efficient fibre mat built by the Sym-Nozzle in the suspension and from the light drainage at the initial stage of the web formation on the Speed-Former and the Sym-Former.

Relative Initial Wet Strengths of some Twin-wire Former Sheets compared with Fourdrinier Sheets

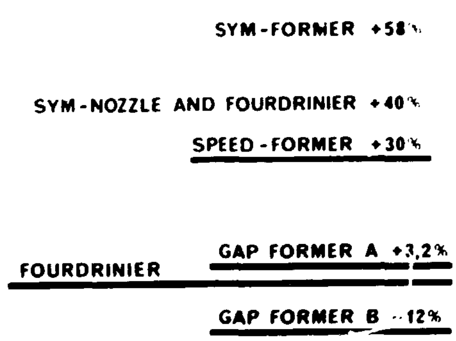

Figure 20

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Selection of forming process

The characteristics of the various former types may be used as criteria when selecting a design to fit a given fibre composition. In general, a fibre which forms a strong web and thus possesses good runnability can make newsprint at high speed and high efficiency on a twin wire former, while the Sym-Former wet end concept would be the most suitable for a fibre of low wet strength. The most convincing proof of the suitability of a former design to a given fibre must probably be looked for in test runs using various fibre materials. Our own experience is obviously limited to the fourdrinier and Valmet formers (Figure 21).

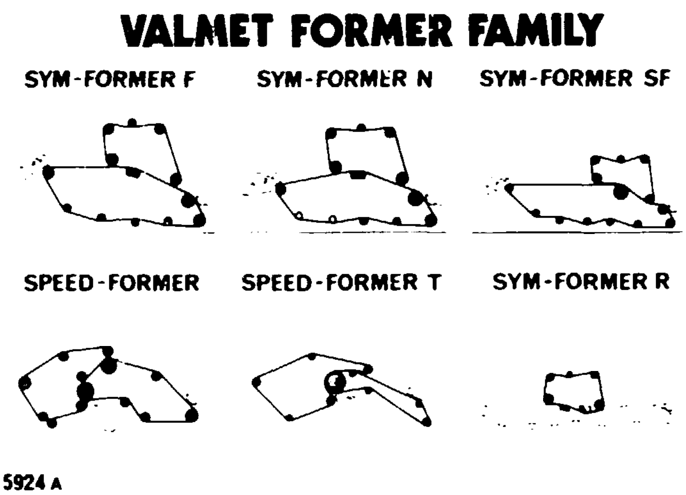

Figure 21

TRIAL RUNS WITH SOME UNCONVENTIONAL FIBRES

Salix newsprint trials

In 1972 Valmet Oy took part in trial runs having the purpose to find out the suitability of some leaf trees growing in Argentine to be used as raw material of newsprint. The amount of lumber, 197 ton, was divided as follows: 40 % sauce alamo (Salix), 40 % sauce americano (Salix) and 20 % alamo (Populus). In addition to this, chemical pulp from Chile was used for furnish compositions. Laboratory tests of fibres, defibration and pilot plant trials as well as a mill scale trial run on the Fourdrinier paper machine of Enso-Valmet Oy were carried out. At that time it was not possible yet to test Valmet Twin-Wire solutions on a wide trial run like this. The results (Table No. 1) showed that the machinery used suited very well for producing pulp and paper of the raw materials mentioned above. The paper technical and printing properties of the newsprint produced are fully competitive with the corresponding values of average Scandinavian newsprint.

Bagasse trial runs

Valmet Oy has carried out trial runs using both the Sym-Concept and the fourdrinier pilot machines for sheet formation. The amount of bagasse fibres used for the trials ranged between 75 % - 95 %. The objects of research were the processibility of furnish on the machine as well as the properties of the sheet produced.

Fourdrinier

The drainage of bagasse furnish on the wire section does not differ very much from that of conventional newsprint furnish. An essential thing about the process is, however, that the top surface of the web retains dusty fines, which do not get bound t the rest of fibres. When coming into contact with press rolls and dryers the fines stick firmly to them causing breaks. The processibility of the bagasse web is weak when running on the Fourdrinier.

In order to maximize the original wet strength of the web, the Fourdrinier is not the right solution. The addition of fillers lowers the strength of the web, which is weak enough even otherwise.

The ash distribution in the thickness direction of the sheet is very unsymmetrical. On the wire side fillers and fines are rinsed off almost entirely, whereas plenty of them remain on the top surface. The surface properties measured from the sheet disclose the two-sidedness.

The conventional Fourdrinier machine cannot be recommended for producing bagasse newsprint.

Sym-Concept

By far the greatest amount of fillers and fines in the bagasse web produced on the Sym-Former are concentrated on the middle of the sheet. Disturbing sticking to the rolls and the dryers does not occur. Even the strength of the wet web is good (Figure 22), higher than that of the normal Scandinavian newsprint on fourdrinier. Thus, to improve the low opacity characteristic of bagasse a lot of filler can be added without any trouble in the runnability of the web. Also low dryness after press section which is typical to bagasse furnish does not matter the runnability of the machine because as low dryness as 35 % gives the same wet strength to the web as that of normal flat wire newsprint after press part. The Sym-Former press is the best as a press solution. Finnish granite proved to be the most applicable material to the centre roll.

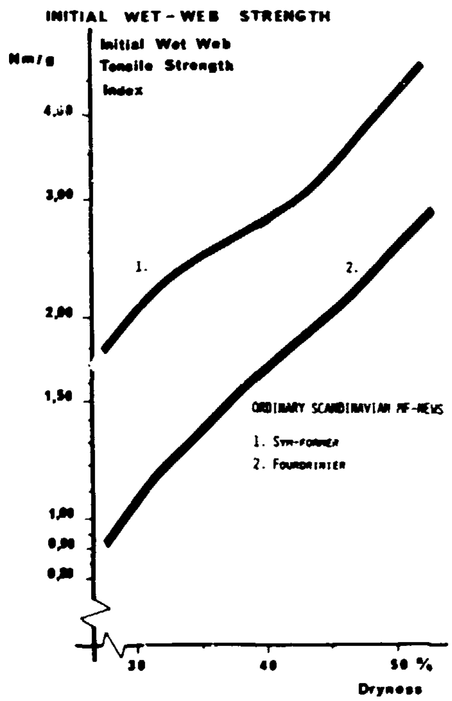

Figure 22

The two-sidedness of the paper produced is very slight: Bendtsen roughness 135/125 =1.08 (with fourdrinier 118/191 = 0.62). Mechanical dry strength values are very high, as that of plybond also (440...490 J/m^2; with fourdrinier 240 J/m^2).

Eucalyptus trial runs

These trials were carried out on the Sym-Former pilot plant making rotogravure printing paper with grammages 40...100 g/m^2 and at speeds up to 12.5 m/s. Ash content in the sheet was as high as 17 % with the total retention of the process up to 88 % and ash retention 40 %. Tensile index up to 52.9 Nm/g and plybond strength 302 J/m^2 were achieved. The furnish was composed of 70 % eucalyptus and 30 % oak. This trial run showed the perfect suitability of the Sym-Former to production of papers from hardwood only, also with high filler contents.

Speed-Former trials using de-inked newsprint waste

The test run was made by the Speed-Former using speed 15 m/s. No problem occurred in runnability with basis weight between 39.7 and 49 g/m^2. The wet web strength was about the same with that of normal fourdrinier newsprint. The formation was excellent and retention about 70 % in all runs. No chemical pulp was added into the furnish.

With the experimental research and a few trial runs mentioned before the suitability of different sheet forming units for paper production from unconventional fibres has been shown. Just to make the choice between formers easier, we have developed a comparison method. A group of characteristics for wet end types have been created such as operational characteristics, machine design characteristics, quality characteristics and application characteristics. Two of them are shown in Tables 2 and 3. All the former types are included: fourdrinier, gap former with stationary drainage elements, gap former with rotary drainage elements, Valmet Speed-Former and Valmet Sym-Former. A scale from 1 to 4 is used, 1 being the best, 2 the second best etc.

These few examples - I hope - will give some idea for the selection of a suitable former for making newsprint from more or less unconventional fibres.

TABLE NO. 1

PAPER PROPERTIES OF THE NEWSPRINT MADE AT ENSO-VALMET PAPER MACHINE ON JUNE 27, 1972

Furnish 20 % Chilean sulphate pulp and
80 % refiner groundwood made from the blend of 40 % Salix Americano, 40 % Salix Alamo and 20 % Alamo.

	Roll I	Roll II	Roll III
Chem. pulp content, %	19±2	18±2	20±2
Basis weight, g/m^2	52.5	54.0	53.9
Thickness, mm	0.090	0.091	0.084
Density, g/cm^3	0.583	0.593	0.642
Breaking length //, m	3040	3400	4470
" " ⊥, m	1360	1440	1870
Tear factor, //	44	41	45
" " ⊥	59	57	64
Burst area, m^2	7.9	9.0	13.7
Roughness, ws, ml/min	153	138	123
" ts, ml/min	139	128	112
Hardness, ws, %	41.9	36.6	38.7
" ts, %	41.0	37.5	38.0
Porosity, ml/min	1190	815	560
Oil absorbensy, ws, s, KCL			
(Patra, visc. 2000 cP)	0.9	1.8	4.7
Oil absorbency, ts, s	3.4	7.5	19.0
Oil absorbency Unger, ws, g/m^2	39.9	36.8	24.1
" " " ts, g/m^2	36.3	33.4	27.4
Formation	55	63	66
Brightness, %	65.9	65.7	63.4
Opacity, %	91.3	93.1	91.5
Scattering coefficient, cm^2/g	514	556	483
Luminance factor, %	72.2	72.0	70.7
Dominant wavelength, µm	571.8	571.8	573.6
Excitation purity, %	7.7	5.4	6.6

TABLE NO. 2

QUALITY CHARACTERISTICS FOR WET END TYPES

	Four-drinier	Gap former S	Gap former R	Valmet Speed-Former	Valmet Sym-Former
Formation	3	2	4	2	1
Two-sidedness	4	3	3	2	1
Z-direction strength	2	4	3	2	1
Porosity	low	high	high	high	low
Wet web strength	2	4	3	1	1
Pin holes	1	3	2	2	1
Linting characteristics	3	1	2	2	2
Wire mark	1	2	3	2	1

TABLE NO. 3

APPLICATION CHARACTERISTICS FOR WET END TYPES

	Four-drinier	Gap former S	Gap former R	Valmet Speed-Former	Valmet Sym-Former
Basis weight range	1	3	3	3	2
Grade flexibility	1	2	2	2	1
Furnish characteristics	1	3	2	2	1
Filler content	1	4	3	2	1

TABLE NO. 3

APPLICATION CHARACTERISTICS FOR WET END TYPES

	Four-drinier	Gap former S	Gap former R	Valmet Speed-Former	Valmet Sym-Former
Basis weight range	1	3	3	3	2
Grade flexibility	1	2	2	2	1
Furnish characteristics	1	3	2	2	1
Filler content	1	4	3	2	1