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HOW TO BUILD A LOW COST PAPER MILL IN DEVELOPING COUNTRIES 1/

by

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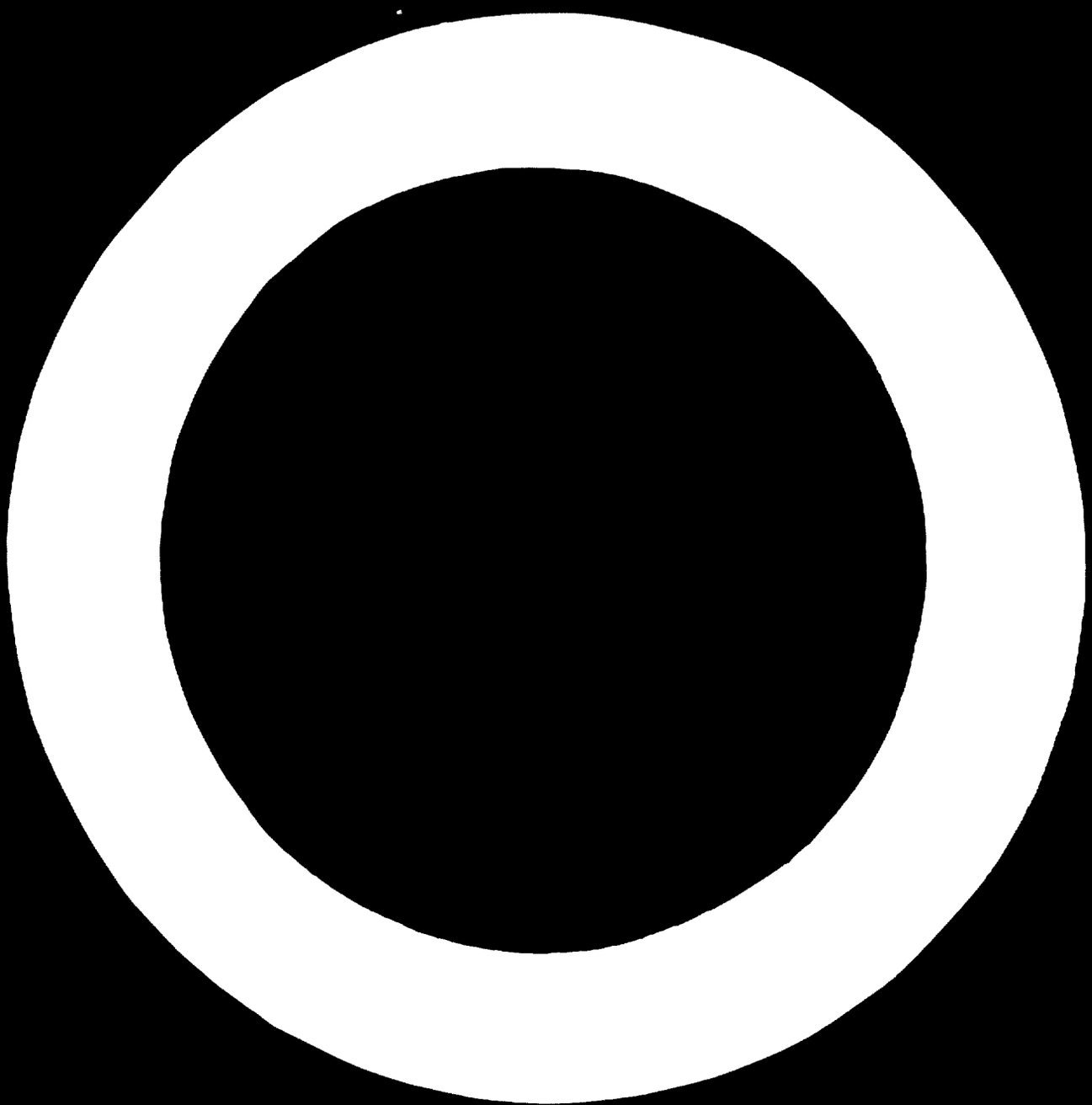


Table of Contents

Pictures

How to build a low cost Paper Mill in Developing Countries

ALBRECHT BINDER

1.0 Introduction

Before going into specific aspects of the construction of a paper mill it is my intention to outline the basic points related to a new paper mill project.

These main points include market requirements, raw materials, manufacturing method, plant arrangement and labour.

Market requirements and the availability of suitable raw materials are intimately connected with the decision on setting up a paper mill.

In most developing countries there are locally no raw materials for soft wood long fibres available, while there is usually sufficient basic material for shorter and weaker fibres. Therefore, it is necessary to establish a list of products which can be made of the raw materials on hand. The raw materials are normally of a wide variety of tropical deciduous trees, (not all

of them are suitable for pulping processes), bamboo, bagasse, reeds, grasses etc. The fibres of these materials are suitable for so called "Cultural Papers" including writing and printing papers. With these papers, strength is of secondary importance. Printability, opacity and smoothness are the major requirements which can be met with short fibered or lower strength stock and a small portion of long fibered pulp. The latter may have to be imported.

In developing countries with a major issue on improving education there is mainly the need for low cost writing and printing papers. If those grades can be manufactured locally, a fair amount of foreign funds can be saved. Writing and printing paper is a higher grade product than for instance newsprint. For its production is also less capital necessary, based on a certain annual tonnage than for newsprint. It is therefore logical and economical for a country to start a paper industry producing writing and printing papers.

The general location of a mill, relative to the sources of sufficient raw material, water, energy, transportation possibilities etc. and its placement on site have a considerable bearing on the cost, efficiency and economics.

In summary, the main reason for establishing a new paper mill is the economic gain. Since there are large investments necessary, careful technical and economical consideration has to be given to all aspects, which include the following:

a) suitable fibre material in the required quantity for the proposed products

b) thorough market studies

c) careful selection of plant location, with respect to supplying the fibrous material to the mill and transportation of the finished product to the customer, availability of process water, supply of power and fuel, suitability of the ground properties, availability of suitable labour and an effective management

d) capital cost estimates, production cost estimates and predictions on earnings.

If the above items are answered in a positive sense the construction of a paper mill seems to be justified.

Generally it can only be expected that an Integrated Pulp and Paper Mill is an economical proposition in developing countries. This point however is not subject to this paper and therefore is not delt with.

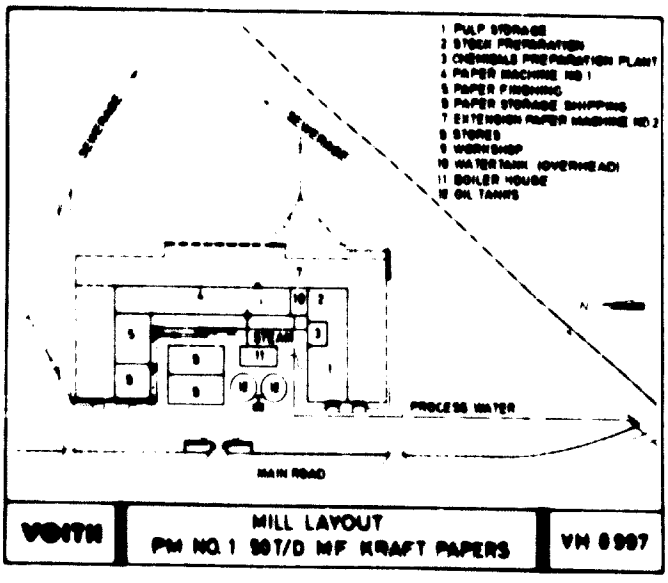
2.0 Mill Layout and Design

The basic objective in mill layout and design is economy with respect to capital and operating cost.

After having established the mill capacity and the process itself, there is generally not too much that can be done to reduce cost through layout and plant design. In order to minimize cost influenced by these factors a layout and design should be adopted that requires a minimum of materials for buildings, piping, ducts, cables, conveyors etc. Also a design should be proposed for minimum labour for the construction part. As an average the plant construction costs about 20 - 30 % of the total investment. Therefore, only this percentage can be influenced by the plant layout and design.

However, no sacrifices must be made to operational conditions in order to save on the initial investment. On a long term basis this is usually of much greater importance.

The mill site has to be tested for its suitability from the construction point of view. Geological maps often do not give sufficient support for a decision. Ground drillings should therefore be made to be sure that only minimum foundation costs will be involved. If this point is not checked carefully, tremendous unexpected costs can arise.



No. 1

Picture No. 1 shows an arrangement for a paper mill as it is often adopted for low output mills with a production of 20 - 50 t/24 hrs. This setup has a U-shape thus giving a very compact arrangement. The right wing takes the pulp storage and stock preparation. The upper section, the approach flow system and the paper machine and in the left wing are the finishing and storage section and the shipping department located. Auxiliary departments are arranged as to have the boiler and power plant as well as the maintenance department in a central location. The dotted lines indicate the possibility for later expansion.

It is important to arrange the buildings with respect to the cardinal point, wind directions and to traffic connections by road and rail.

Process water supply should come from a neighbourhood area, as to save a costly long pipe line. Consideration has to be given to a possible affluent disposal line.

In warm climates cost savings are possible by outdoor installations of chests, tanks etc. Pulp storage very often can be done just under a simple roof.

Construction material used should be selected from a point of availability in a certain country. It means that concrete and brick is cheaper in one country and should therefore be used while in another it might be structural steel.

3.0 Checklist of Equipment for Small Paper Mill Installations

After making some general comments on establishing a paper mill in developing countries and just touching the layout and design of a mill, I would like to give in the following a list of machinery and equipment required for a small paper mill operation:

3.1 Pulp storage

3.2 Pulping and stock preparation

3.3 Approach flow without or with fiber recovery

3.4 Paper machine

3.5 Finishing equipment (winder, super calendar, cross cutter etc.)

3.6 Paper storage

3.7 Auxiliary equipment

3.7.1 Steam generation

3.7.2 Electricity supply

3.7.3 Process water supply

3.7.4 Effluent disposal

3.8 Ancillary equipment

3.8.1 Workshop

3.8.2 Cranes and hoists

3.8.3 Conveying equipment and scales

3.8.4 Laboratory

3.8.5 Fire fighting equipment

3.8.6 Outside pipelines

3.9 Clothing, belts, hosing

3.10 Spare parts

The major items of this list will be delt with in the following sections, whereas the main emphasis will be put on the paper-making equipment itself.

4.0 Stock Preparations, Approach Flow Systems and Paper Machines

Generally, paper machines, their stock preparation and approach

flow systems for developing countries should not be designed as single purpose equipment. It has to be as universal as possible even if the overall efficiency will suffer somewhat by this task.

In the following various production lines will be discussed with the idea to work out possible savings for simple - from the operating standpoint - and low cost installations.

Beginning a paper industry in developing countries, if there are no special products required by the export industry, the following sequence might be adopted:

a) writing and printing papers

b) M.F. wrapping papers, corrugating medium etc., with low strength characteristics, because of the fibers available

c) MG-papers

d) board, liner

e) sanitary crepe

Writing and printing papers can also be made with little variations to machines for papers as specified under b, c, and d.

In this paper, I will not deal with newsprint mills although newsprint might be a big import item in developing countries.

Newsprint is also the lowest priced grade of paper. Only large mills based on soft wood as raw material and with low wood and power costs can compete with world market prices. Newsprint mills in North America and Scandinavia have daily capacities between 500 and 2000 tons.

4.1 Minimum Paper Machine Sizes and Production Rates

In developing countries very often the market conditions decide in favour of a small paper machine. In addition it is also easier to train people on a smaller machine when starting a paper industry. However, there is a minimum production rate and paper machine size for various paper grades which should not be fallen short off.

In my estimation the following data should be regarded as minimum production figures for machines making:

a) Writing and printing paper, M.F. wrapping paper or corrugating medium

minimum wire width	approx. 2,500 mm
Basis weight	approx. 60 - 125 g/m^2
Minimum gross production	approx. 30 - 40 t/24 h depending on basis weight

b) M.G. Kraft/Tissue with Pre-Dryer Section and M.G. Cylinder

minimum wire width	approx. 2,500 mm
basis weight	approx. 40 - 100 g/m^2
minimum gross production	approx. 25 t/24 h

c) M.G. Kraft/Tissue, Yankee Paper Machine

minimum wire width	approx. 2,000 mm
basis weight	approx. 14 - 35 g/m^2 on the wire
minimum gross production	approx. 10 t/24 h

d) Sanitary Tissues, Yankee Paper Machine

minimum wire width	approx. 2,000 mm
basis weight	approx. 14-35 g/m^2 on the wire
minimum gross production	approx. 10 t/24 h

e) Cylinder-Mould Board Machine

minimum wire width	approx. 2,500 mm
basis weight	approx. 250 - 800 g/m^2
minimum gross production	approx. 40 t/24 h

These figures stand also for combined board machines with a Fourdrinier and cylinder moulds.

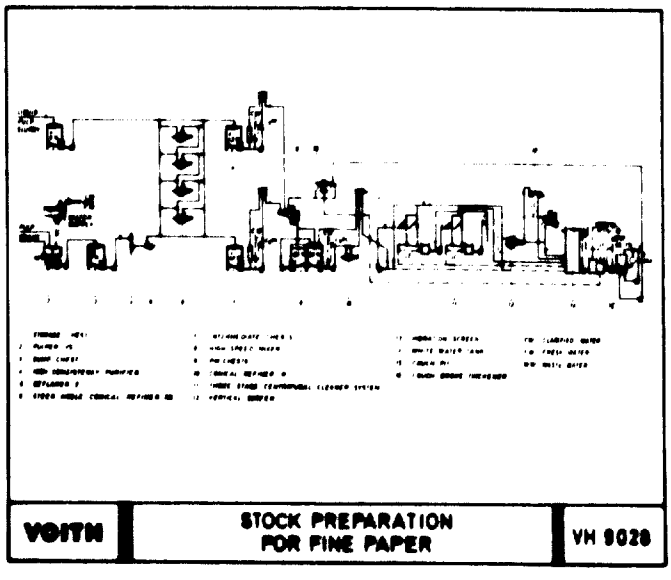
f) Fourdrinier Board Machine

minimum wire width	approx. 2, 500 mm
basis weight	1 Fourdrinier up to 300 g/m2 2 Fourdriniers up to 400 g/m2 3 Fourdriniers up to 500 g/m2
minimum gross production	approx. 40 t/24 h

This type of a board machine is unlikely being built for a developing country.

4.2 Installation for Writing and Printing Papers

The stock preparation as shown on picture 2



No. 2

is based on the idea that two different raw materials are being used. Number one are fibres of tropical origin like bagasse, bamboo, eucalyptus etc. which are pumped from the attached pulp mill into the paper mill. Number two is imported long fiber pulp as for instance bleached Kraft pulp.

Pulp from the pulp mill is being stored in the liquid state in a chest. The imported long fibres will be pulped in a Pulper. Refining is done separately for both components, however, refiners can be

switched from one line to the other as the proportions require.

In case only dried pulp is being used, line 1 has also to be equipped with a pulper.

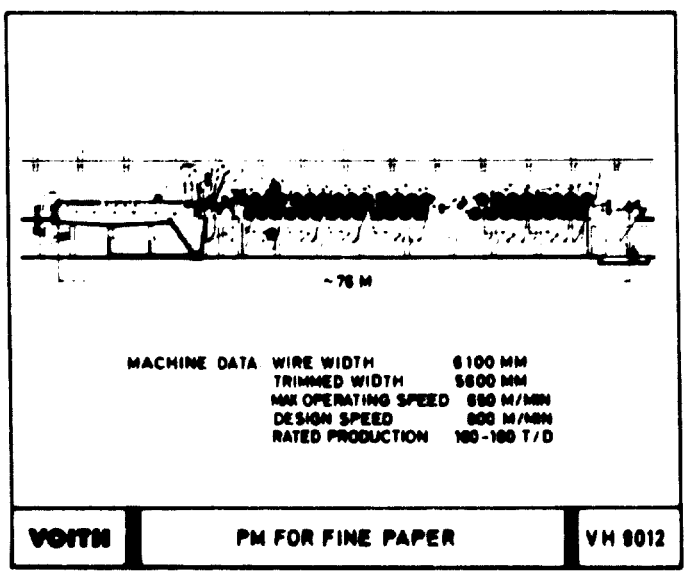
If there is any possibility for using only one grade of pulp or refine two grades in a mixed state, one line can be eliminated. A coarse cleaning with high consistency cleaners is recommended to separate heavy particles from the pulp for protection of the following equipment. A deflaker will only be installed with increasing quality needs. There are intermediate chests and a troublefree proportioning system with niveau tanks. An intensive mixing effect of all components and additives is achieved with a so called fast mixer ahead of the paper machine chests.

It is recommended to install a steep angle refiner to shorten the fibres for an improved formation. The consistency controller is installed in the line to the niveau tank from which the basis weight is controlled. In a low cost mill, there will be no cleaners installed. If for special quality reasons cleaners are necessary then a 3-stage system should be adopted to avoid high fiber losses. A vertical screen for final de-flocculation and for the protection of the wire from damaging particles is a must. A wet-broke system under-

neath the couch roll for the total production and for the fourdrinier trimmings cannot be neglected. The broke is returned from the couch pit via a thickener directly into the system. Dry broke is repulped in the main pulper. There will be no fiber recovery necessary.

The advantages of a system as just described is its simplicity. There are only a few uncomplicated and low maintenance machines involved and litte instrumentation is required. The stock preparation plant is very versatile and simple to operate.

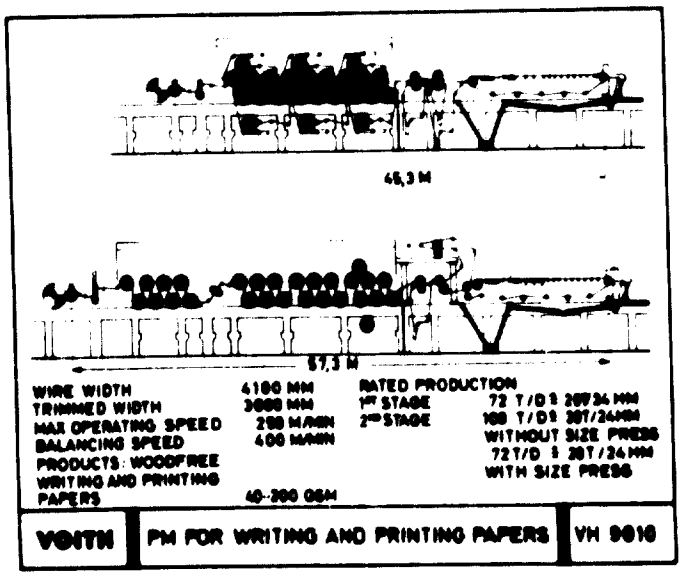
A system as of above will be suitable for all grades of paper of chemical or semi-chemical pulp. The layout as on the diagram is for a production of 40 t/24 h.



No. 3

Picture 3 shows a machine for writing and printing papers as it

would be built in a country with a highly developped paper industry. This machine consists of a closed headbox, Fourdrinier with ceramic-covered foils, wet suction boxes, forward drive roll, press section with a compact double press, consisting of a suction press roll, a smooth center roll and a third rubber-covered swimming roll, followed by a third press with a swimming roll and an offset press, dryer section with hot air rolls, enclosed gear drive for the dryers, intermediate 2-roll calendar stack and size press, 4-roll end calendar stack with two swimming rolls and a pope-type reel.



No. 4

A low cost paper machine, with approximately 40 t daily output, easy to operate and not requiring highly skilled labour,

could look as shown on picture 4. The paper machine has an open-type headbox which is sufficient for speeds up to 200 or 250 m/min. These speeds are high enough for starting a paper mill. The Fourdrinier section can be of the knock-down type with a wire width up to 2.5 m. However, it is recommended to use the Cantilever type for wider machines, for the danger of damaging the drainage elements while changing a wire will be too big. As drainage elements, low cost, low mainterance and simple to operate table rolls are recommended. They will be satisfactory with respect to the paper quality especially with relatively low operating speeds. The press section will have two straight-through presses with a fabric in the first press for high water removal. The 2nd press will have - at least for the beginning - smooth rolls and no Venta-nip bottom roll because the danger of damaging felts is too great before the operators are used to handle the machine. If there are no special quality requirements, the smoothing press can be avoided. The simplest dryer section is with open gearing, standard scoops in the dryers which work trouble-free up to a speed of 400 m/min. with dryers of 1500 mm diameter. Felt dryers should be used in all felts. Automatic felt guides are recommended to avoid felt run-offs, but for felt tension a simple weight loaded tensioner is adequate. For all positions in the wet end and dryer section a hand-lubrication system is proposed. A size press should be provided only for later installation. At the end is a 4-roll calendar

stack without swimming rolls and a Pope-type reel. This machine would be completely driven by a line-shaft drive which does not require highly trained experts to maintain. A paper machine as just described is kept very simple from the engineer's standpoint and for this reason it is simple to operate.

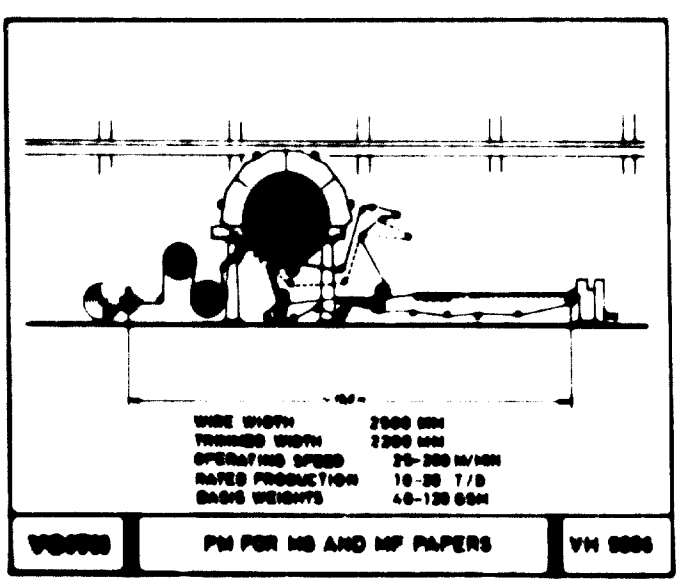
For any paper machine built for a low production capacity a possible expansion at a later date should not be ruled out. Also on picture 4 it is shown how the above described machine for writing and printing papers can be expanded for higher production or improved quality at a later date without affecting the initial costs appreciable.

For operating speeds above 200 - 250 m/min. a closed-type headbox is recommended. At higher speeds a vacuum pick-up would improve the efficiency since in most developing countries usually only short or weak fibred stock is locally available which has a low initial wet strength. The dryer section has to be extended proportionately, with the rate of production increase. The installation of the size press will satisfy wider market requirements.

It was earlier mentioned that paper machines for developing countries should be built as versatile as possible.

A machine as shown on picture 4 could make the following grades: writing and printing papers from 50 to 120 g/rn^2 M.F. wrapping papers, corrugating medium from 50 to 150 g/m^2, solid board up to 250 g/m^2, or in other words all kinds of M.F.-papers of chemical or semi-chemical pulp.

In case a country has a need for writing and printing papers as well as for light weight MG papers perhaps to wrap some of its export products, both grades can be made on a machine as shown on picture 5.



No. 5

The cost for a Yankee machine with two after dryers is fairly

low compared to a standard Fourdrinier machine. Of course the production of this machine is also lower. In case MG papers are produced, the drying process is finished at the end of the Yankee dryer. For the production of writing and printing papers the Yankee would be just used as a normal dryer as are the two after dryers. The writing and printing papers of this machine will have a slight two-sidedness which in most cases is of no significance. The stock preparation and approach flow system as discussed before would of course also suit this machine.

With the discussion of the above two types of paper machines, I also wanted to show the possibility of combining various paper grades on one machine.

4.3 Installation for Board and various Paper Grades

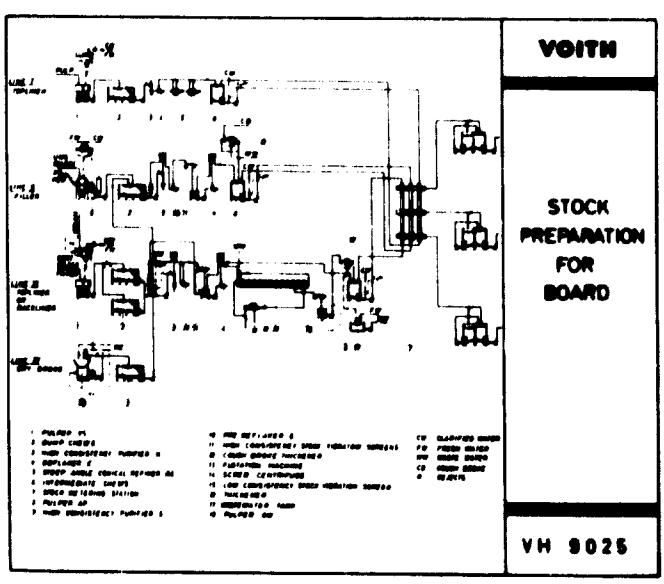
The installation of a board machine can for a developing country just be as important as a machine for writing and printing papers. This is the case when board is required to export some of the country's products.

The stock preparation for a board machine should have a minimum of three lines i.e. one for the top liner, one for the filler and one

for the back liner. If virgin pulp of various quality is used for the three layers each stock line would have a set up as it was described before for a machine producing writing and printing or wrapping papers. It means it would be a very simple stock and approach flow system. The cost for this system could be kept quite low.

In case waste paper is used for some layers, a more elaborate stock preparation system is required. Since there is usually a shortage of waste paper collected in developing countries it should be looked into the possibility of importing suitable waste paper for board production. This however can only be economical if there are short distances to cover for transporting imported waste paper to the board mill.

The stock preparation for a board machine using waste paper would have a set up as shown on picture 6.



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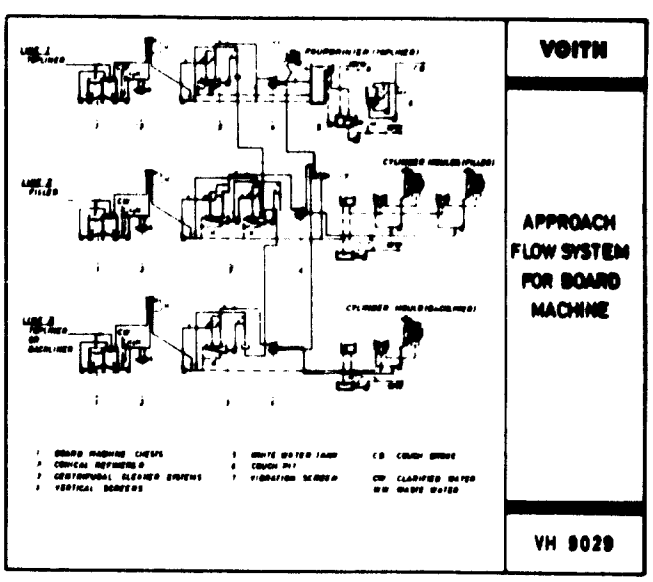


No. 6a

The top liner would be of virgin pulp coming from a batch operated pulper. From the dump chest the stock will go through a coarse cleaning system followed by a deflaker and refiners and into an intermediate chest.

Line two for the filler is using mixed waste paper. It has a continuous pulper with a ragger to take out strings, wires, plastic foils etc. This pulper has a gate on the bottom to discharge heavy particles such as metal, rocks and glass. The pulper does not have to be stopped while opening the gate. The pulper is followed by a dump chest, high consistency centrifugal cleaners with a high cleaning effect using the necessary differential pressure. In this case pre-deflaking is recommended to open-up fiber bundles and separate dirt particles from the fibers without shortening them. Using the high consistency screening system and final deflakers no thickener is required. Final deflaking is necessary if specks coming from the filler are not accepted in the board.

Line three for the back liner is as per line two. It can be extended with a deinking plant as shown on the diagram. This line could also be switched to the top liner. I will not deal with the deinking process since this is subject to another paper of this meeting.

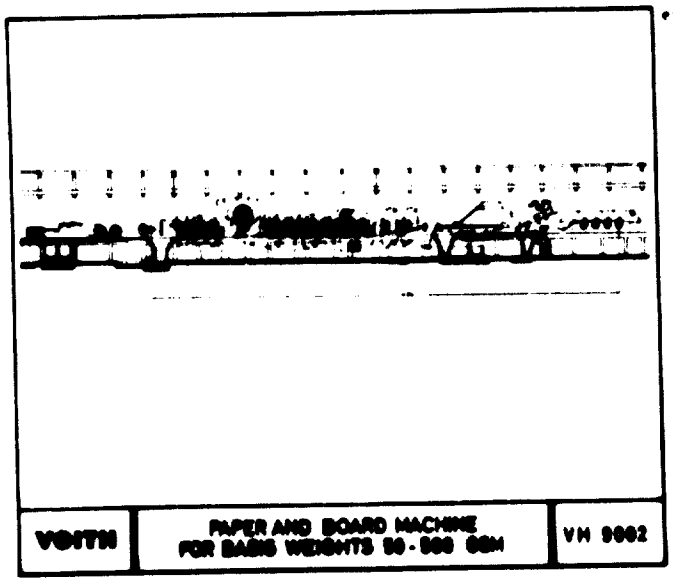
The diagram shows also a separate line for the dry broke. The dry

broke however could go direct into the pulper of line two, thus saving this line.

Stock from the intermediate chests will go over simple distribution troughs and will flow metered into the pre-chests. There will be consistency controllers at the intermediate chests and a constant level is kept in the troughs by an overflow. This system is uncomplicated and of low cost since it eliminates level controllers and flow meters. There is the possibility of mixing the components of all lines.

In the approach flow system will be refiners for a final even-out-effect of the stock. Cleaners as in the diagram are not necessary for this purpose and final screening will be accomplished using a vertical screen for each cylinder mould. The rejects from all vertical screens will go to one vibrating screen. (Picture 6a).

Both stock preparation systems as described would suit a very versatile Board and Paper Machine as shown on picture 7.
A machine of this type is recommended if the main emphasis is put on the production of board, but paper has to be manufactured as well. I find a machine of this type for its versatility very interesting for a developing country and describe it therefore in more detail.



No. 7

Voith has built a machine for this purpose with the following data:

wire width:		2 675 mm
effective width of cylinder moulds:		2 585 mm
trim:		2 285 mm
operating speed range as board machine		12 - 84 m/min.
only with fourdrinier up to		144 m/min.
production rate a 100 % efficiency		45 t/24 h
grades:	white covered board	200 - 500 g/m2
	Manila grey back	
	chipboard	
	corrugated medium	100 - 150 g/m^2
	liner board	
	paper	50 - 150 g/m^2

This machine consists of:

4 restricted flow vats

1 reversing suction roll

2 pre-presses with top felt

1 transfer felt to Fourdrinier

1 Fourdrinier section with a 22 m long wire

1 pressure dandy

1 suction couch roll with lumpbreaker roll

1 straight through press

2 reversing presses

18 pre-dryers 1500 mm diameter

1 Yankee dryer 3600 mm diameter

6 after dryers

2 swet dryers

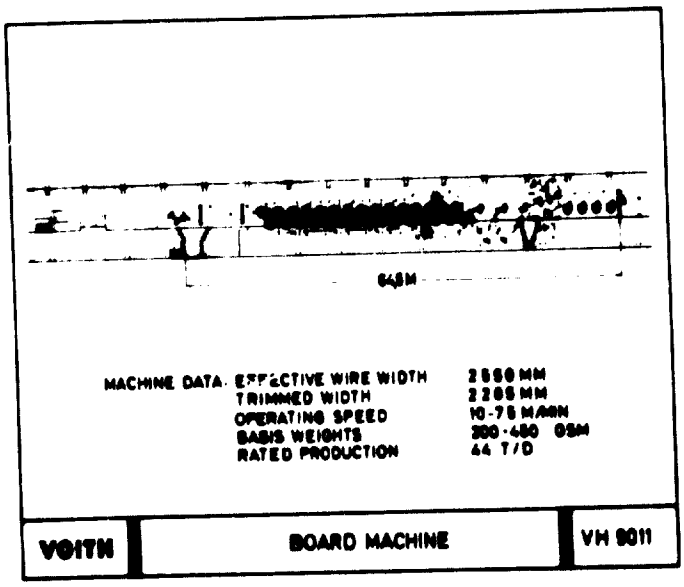
1 7-roll calendar stack

1 pope reel.

In addition to the low cost principle as described for the machine for writing and printing papers, this machine has a knock-down Fourdrinier since with low speeds a long wire life is reached. Only the first dryer group is felted and has felt dryers. All other groups are equipped with dryer fabrics which do not require felt dryers.

This paper and board machine is number 2 machine in a mill which started to manufacture paper 15 years earlier. The little more complex operation of the machine because of the combination cylinder moulds / Fourdrinier did not cause problems with the mill personnel.

If only board with basis weight from 200 to 450 g/m^2 are intended to be produced and there are no special requirements for a one-side MG-finish a machine as shown on picture 8 is proposed.



No. 8

The one-sided finish of lower requirements will be achieved with water doctors on the first calendar stack. The tonnage on board

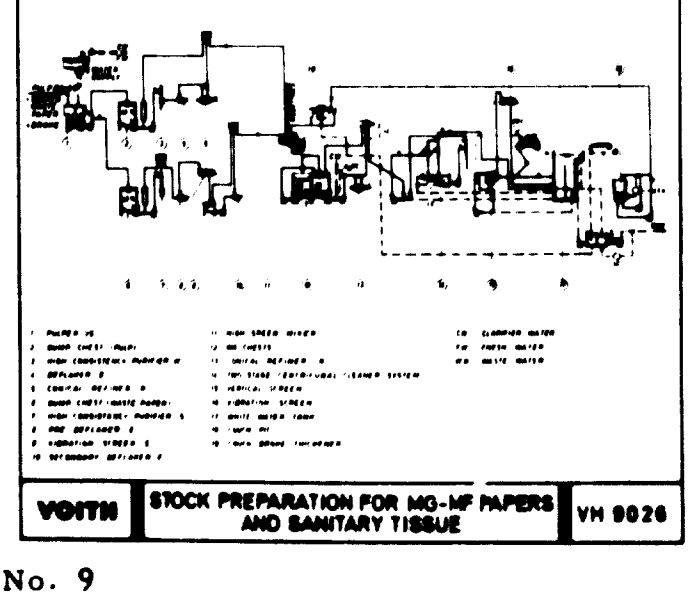
and heavier paper grades will for both machines be the same. The cost for the board machine as of picture 8 are considerably lower, because of its simpler arrangement. There is however not the same versatility.

The above board machine is intented to be extended by three to a total of seven restricted flow vats. This machine can then produce board up to 800 g/m2.

4.4 Installation for Sanitary Tissue and MG Papers

The production of Sanitary Tissue and light weight MG papers can be combined on one paper machine if it cannot be filled with orders of one grade, and if there are no special requirements for the MG-finish.

A simple stock preparation would suit the production of both grades. It is shown on picture 9 as line one.



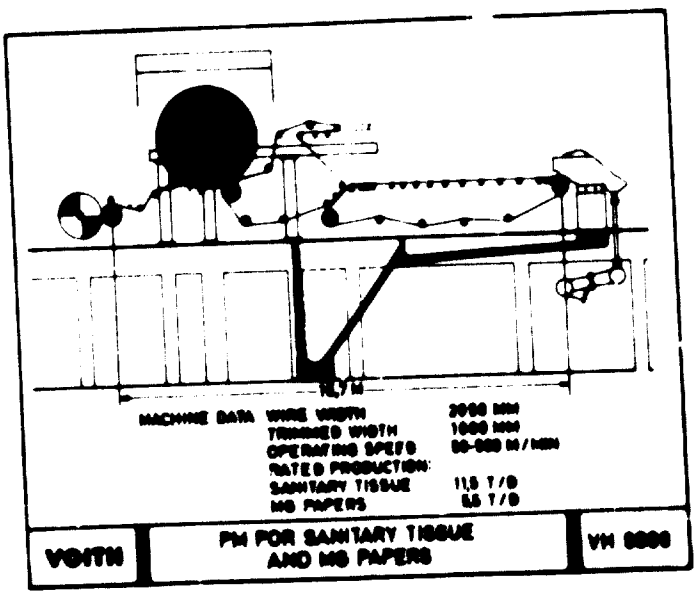
No. 9

It contains coarse cleaning, deflaking and refining.

In case there is the intention of using waste paper as sole stock supply or in any combination with virgin pulp a flow as per line two has to be installed or added.

For an installation using waste paper, the vertical screen in the approach flow system has to be equipped with a slotted basket to separate cubical particles.

A small paper machine with an output of about 11 t/24 h of sanitary crepe and 5.5 t/24 h of MG-papers has a set-up as per picture 10.



No. 10

The main data of this machine are:

wire width:		2050 mm
trim:		1800 mm
operating speeds:		50 - 500 m/min.
Products:	1) sanitary crepe	14 - 20 g/m2
	production rate	11,5 t/24 h
	2) MG-papers	25 - 50 g/m2
	production rate	5,5 t/24 h

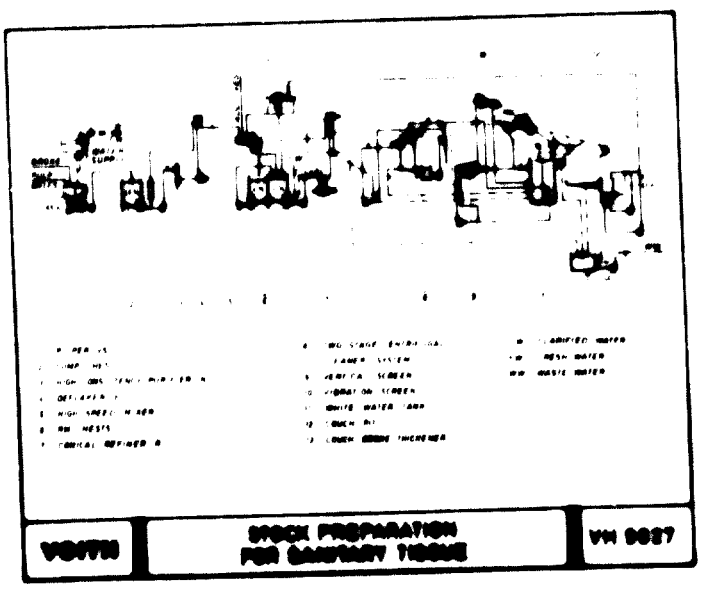
The output of MG-papers on this machine is very low, since there is no suction couch and no wet press installed. This, however, is satisfactory if MG-papers are just regarded to fill the capacity of the paper machine.

5 Installation for Sanitary Tissues

We had just recently various requests from developing countries for quotations for a small complete plant to produce only sanitary tissue. The daily output was 10 - 15 t.

The stock preparation for such a plant can be kept very simple. As shown on picture 11, there is a pulper, storage chest, coarse cleaning with a high consistency cleaner. Here again it is possible to work without a deflaker. Mixing of all components including

broke is done by a fast mixer from where the stock reaches the machine chest.

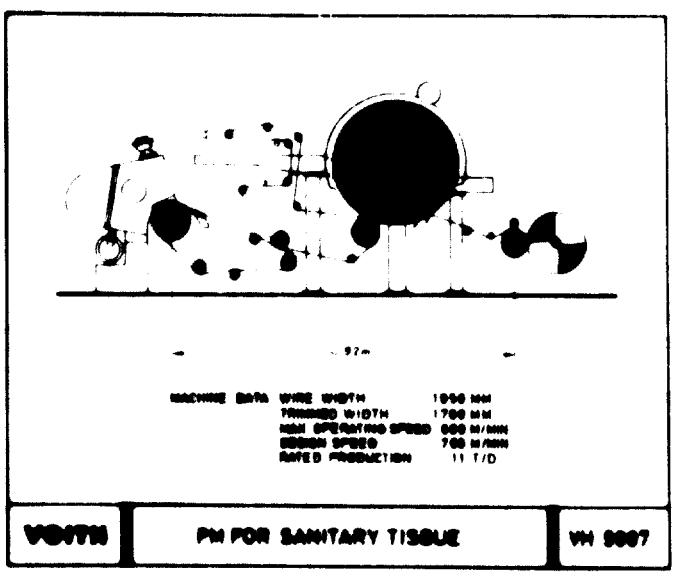


No. 11

All refining, which is in the case of a tissue mill very little, will be done in the approach flow system after the machine chests. Special refiner fillings are used for this grade to achieve a high long-fibre content and do as little fibre cutting as possible. The advantage of this system is that there are no intermediate chests and the machine tender can instantly change the stock properties.

If installation cost have to be saved no cleaners as well as no after-

dilution will be installed. In this case there is only fine-screening done by the vertical screen ahead of the headbox. The couch broke is directly returned into the stock flow via a thickener. All dry broke is going through the main pulper of the stock preparation.



No. 12

Picture 12 shows a small sanitary tissue machine which Voith has especially designed for developing countries.

This machine has the following data:

wire width:	1950 mm
trimmed width:	1700 mm
operating speed	100 - 600 m/min.
Yankee cylinder	3200 mm dia.

products:	toilet paper	)
	napkins	) 12 - 28 g/m^2
	handkerchiefs	)
rated production:		11 t/24 h (at 100 % efficiency)

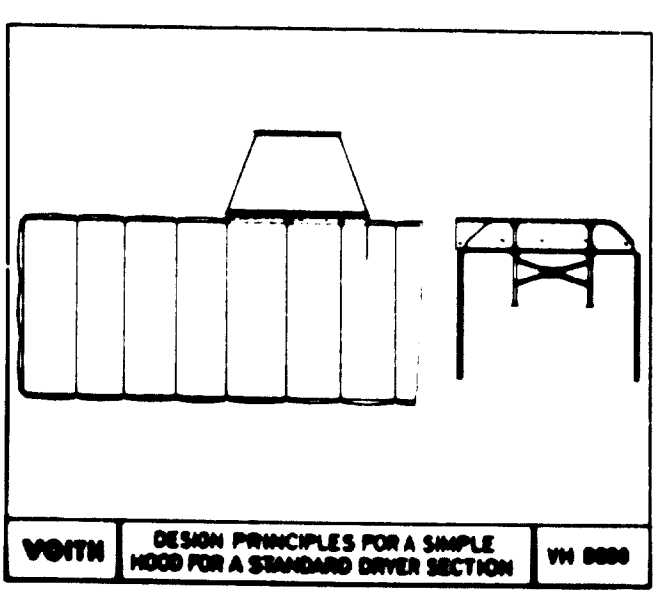
This machine consists of a pressurized headbox, a suction breast roll in a short loop Fourdrinier with only 10 m wire length. A lick-up transfers the sheet to the felt which carries it unto the Yankee dryer. Only one suction press roll is applied to the Yankee dryer. In the first stage a simple vapour extraction hood covers the dryer. For future production increase, a high efficiency hood, steam heated or gas fired can be applied.

Reeling is done with a pope-type reel. A paper machine with this set-up is best driven with a multi-motor drive. It has only 4 drives of which one has to be a helper drive and the speed between Yankee dryer and pope reel has to be varied depending on the creping factor.

A combining winder with two unwind stands for two plies follows the paper machine.

4.6 Paper Machine Hoods and Machine Room Ventilation

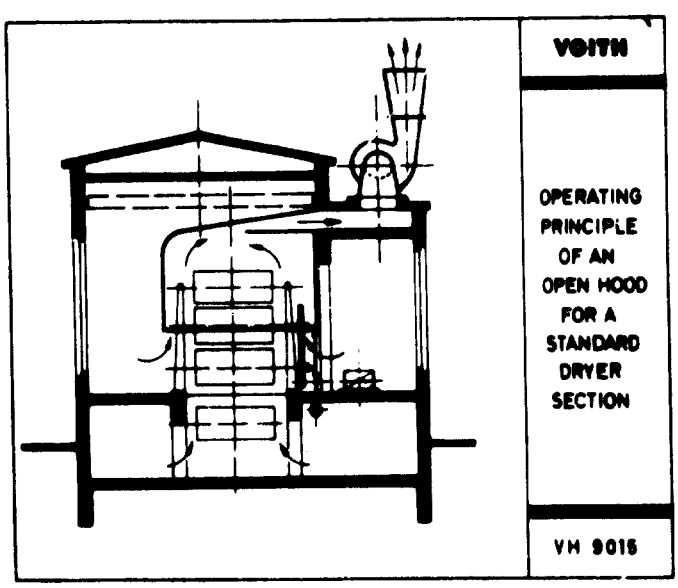
I would like to make some comments regarding paper machine hoods and machine room ventilation for installations in developing countries which are mostly located in a sub-tropical or tropical climate. Under these conditions the ventilation equipment for a paper machine can be limited on removing the water evaporated in the dryer section. Or in other words the dryer section or a Yankee dryer will be covered with an open hood and fans will be drawing the air from the machine room through the hood to remove the vapor. Their capacity depends on the volume of water evaporated and on the outdoor air conditions. The volume of air drawn by the hood from the machine room has to be big enough to keep the dew point of the exhaust air, i.e. vapor plus air sucked into the hood below the wall temperature of the hood to avoid condensation.



No. 13

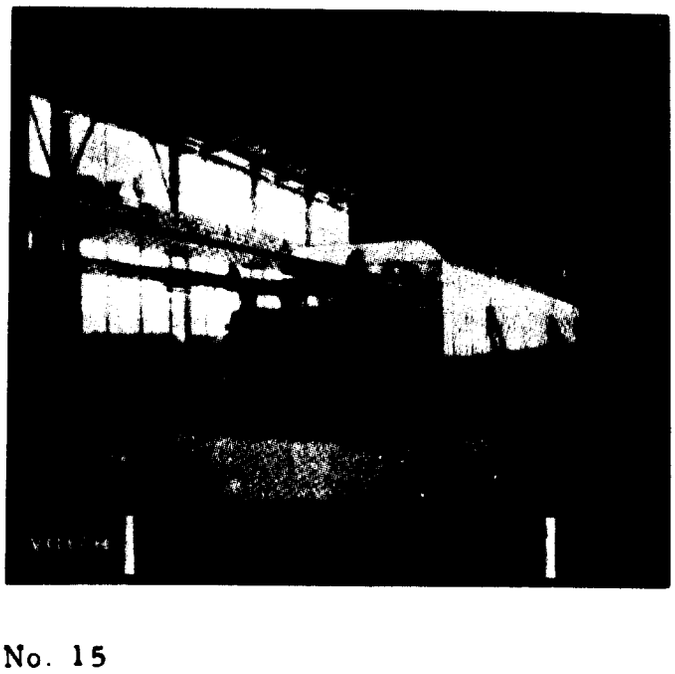
Picture 13 shows the principle of a hood as described for a standard dryer section.

The design of such a hood can be kept very simple. The frame will be fabricated of light structural steel and covered with non-hygroscopical materials such as Eternit, hard board with a protective coating, light metal sheeting etc. The exhaust ducts between hood and fan should be of light metal for corrosion reasons.



No. 14

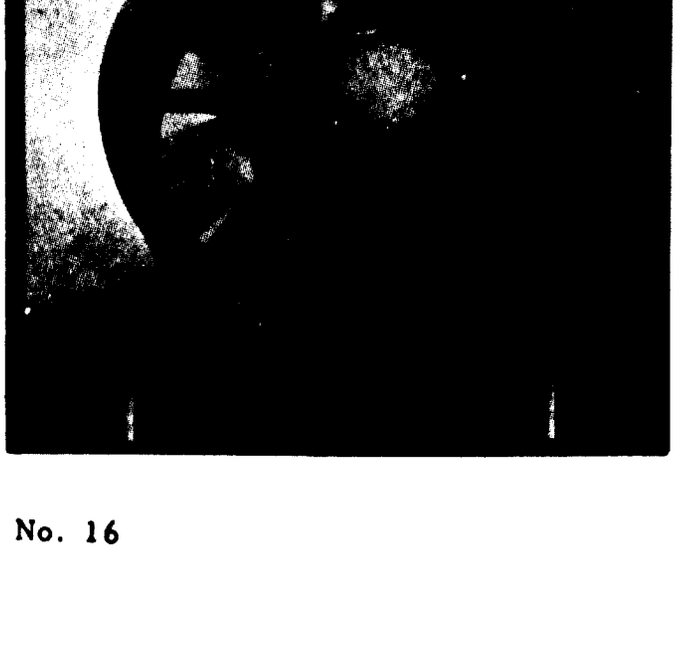
Picture 14 shows the principle of this type of a hood and picture 15 is a photo of such a hood as installed in a Paper Mill in Venezuela.



No. 15

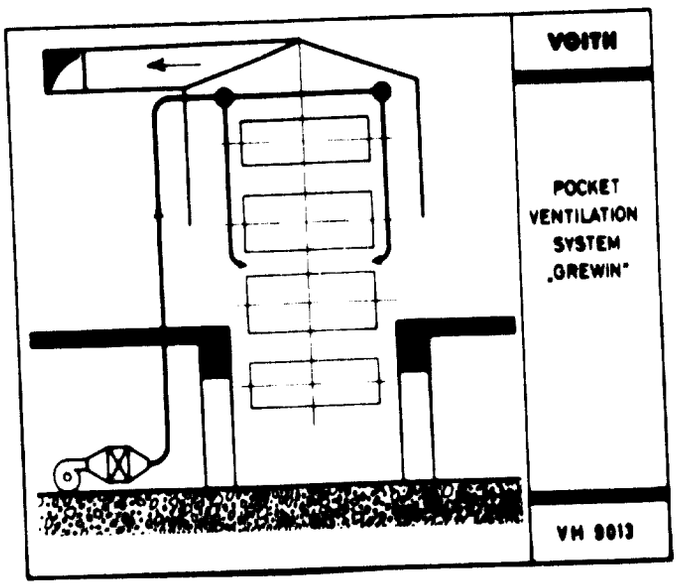
The fans used are of the simple axial design covered with a corrosion resistant paint.

Picture 16 demonstrates such a fan.



No. 16

For paper machine trimming up to about 3 m no pocket ventilation is required. Above that width some kind of cross machine ventilation should be used to avoid stagnation of the vapor in the dryer pockets.



No. 17

Picture 17 shows the principle of a simple pocket ventilation system where air is blown alternately from both sides into the dryer pockets.

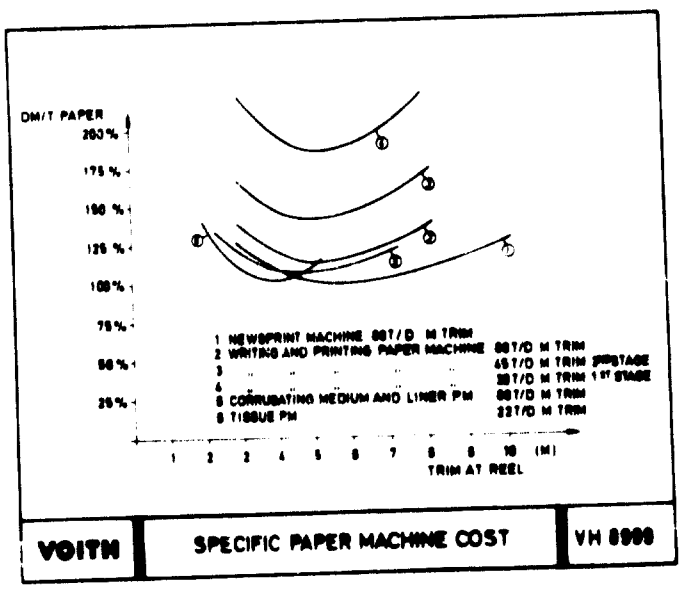
Every machine room has to be equipped with some kind of an exhaust system to remove the unavoidable hot air cushion under the machine room roof. Wall-mounted fans just installed below the ceiling serve this purpose.

The total exhaust from a machine room per hour i.e. air removed through the hood plus air removed under the ceiling will in a tropical climate be up to 20 times the volume of the machine room. The walls of the machine room must have sufficient air intakes in the floor area. The air exchange can then take place from the floor to the ceiling and there will be sufficient fresh air in the machine operator's area.

An elaborate air and machine room heating system is only necessary in areas having outdoor temperatures below 10° C for a longer period.

4.7 Specific Paper Machine Cost

We have recently made a study on the most economical paper machine width with respect to the paper machine cost. We know that there are other points like market conditions, sheet or roll sizes, labour cost etc. which have to be taken in consideration when deciding on the width of a paper machine, however, I find this study very informative and therefore like to show it to you.



No. 18

Picture 18 shows the specific paper machine cost in DM (%)/t paper relative to the trimmed width for paper machines producing various grades. The machines compared with each other have of course an identical layout i.e. same Fourdrinier, same press section and the same number of dryers etc. The same of course is true for the various machine widths for a certain type of machine.

Also the drive for all machines compared is identical. Only on this basis a true comparison is possible.

The diagram shows the following interesting points:

a) for standard Fourdrinier machines with press and

standard dryer sections the most economical width is between 4.5 and 6 m trim. Within this range the lowest paper machine investment is required per ton of paper.

b) Writing and printing paper machines require a higher specific investment than a newsprint machine because they have a lower specific production and they usually have a size press and an after-dryer section. The latter two parts do not add to the output of a machine, but are usually a quality requirement for this paper grade.

c) Curve 3 for the writing and printing paper machines with a specific production of 45 t/24 h m trim is at the optimum approx. 27 % and the machines as per curve 4 with a specific production of 30 t/24 h m trim 72 % higher in specific paper machine cost than the machine with 60 t/24 h m trim. (Machine as per curve 4 is provided for later production increase to 45 t/24 h m trim). The reason for this is, that the machines of all three curves require almost the same high cost wet end, while for the machines with the lower output a much smaller, lower cost dryer section is required. This fact raises the specific cost of a paper machine.

d) For comparison we also included tissue machines in the chart. It may be asked why the optimum for this type of machine is not in line with standard Fourdrinier machines. The reason is that the machines are being built for high operating speeds up to 1200 m/min. and over. These speeds require high heads in the headbox. For instance at 1200 m/min. the necessary headbox pressure is 2.05 atmg. With an increased width the headbox has to be stiffened tremendously to take up the deflection which would increase by the 3rd power. While widening a machine, the cost for a headbox go up much more than what the linear increase in width shows. The other major cost item in a tissue machine is the Yankee dryer. With wider machines its cost also increase more than just linear. These two factors are the reason why the optimum trim for a tissue machine is between 3.5 and 4 m.

The specific productions for the various paper machines as used in the above chart are too high for paper machines in developing countries. It is only the tendency which I wanted to show and this would not change with paper machines of lower specific production.

5.0 Instrumentation in Paper Mills

As an introduction to this chapter, I regard it necessary to outline the meaning of instrumentation. In many industrial branches especially in the chemical industry, instrumentation covers the total of indicating, recording and control instruments including measuring transformers and control valves however not controls for drives and conveying equipment.

In case of a paper mill the instrumentation covers the process measuring and control instruments, all drive controls of constant and variable speed motors and valve controls within the stock- and water-flow system.

In North America and Europe and all other countries with a high industrial standard the layout for measuring and controlling paper mill processes is based on the principle of making the product at high operating speeds with a high efficiency and as little man-hours as possible, since labour cost are a main factor of the total cost of the product. It is a pre-requisite to have personnel with the necessary qualifications for operating and maintaining the installation. Top service from suppliers has to be out of question.

In developing countries there will be for some time to come no

shortage in low cost labour. There will also not be the usual pressure on the cost of the product, for the export will not be in the foreground. Also the free trade within these countries will usually be protected by import restrictions.

Besides all this there is the requirement prevailing to familiarize the personnel itself with the process and its dependences. We know that even in our countries there are partly difficulties with the personnel which is starting up new installations with a high degree of automation until the people have the exact knowledge of the dependences of interlockings and the necessity for various sequences.

The following comments will furnish some detailed information on the application of control and regulating equipment for stock preparation systems and paper machines. Their underlying principle is that the equipment to be used in such systems should be confined to the absolutely necessary and indispensable minimum.

5.10 Stock Preparation

The stock preparation will be discussed in three sections - pulping -

cleaning and refining - and stock blending. Special preparation processes, such as the regeneration of secondary fibres, are not regarded as of topical interest and are therefore not discussed.

5.11 Pulping

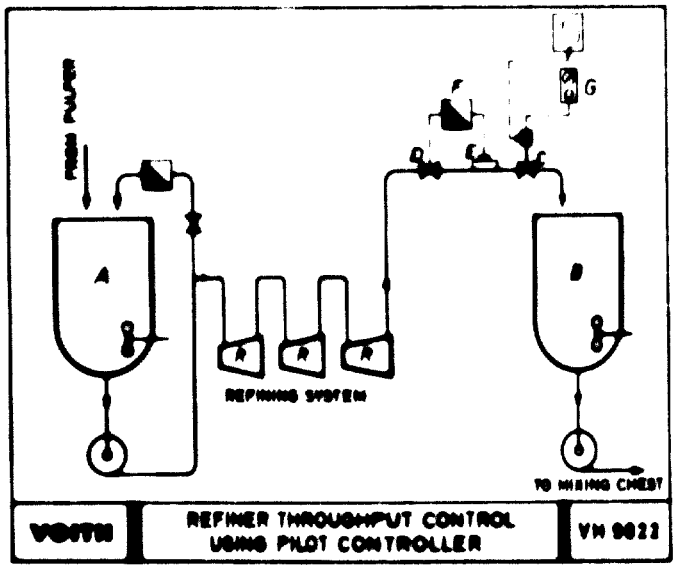
Contrary to pulpers, which in our countries have been fully automated and incorporate pre-selection of water and stock flow as well as fully automatic cycle and time control, for such pulping systems in developing countries the simplest form, that of manual operation, should be chosen. Conveniently arranged hand-operated water shut-off valves and gauge marks inside the pulper vat ensure practically an equally high metering accuracy. Push buttons for the control of the individual drives are grouped together logically in the sequence of the operations and cycles. They are mounted closely to the pulper. The use of simple means in a straight forward arrangement presents an optimum solution to monitor these operating conditions. To what extent the pulper dump chests, and chests in general, should be equipped with level indicators or alarms is a point which ultimately depends on the local conditions. When the chests are open and can conveniently be inspected from the machine floor, the mill can dispense with the installation of special level gauging equipment and remote

indicators. However, if accessibility is poor or the information on the filling level is also of interest to other points in the production range, it is indicated to put forward a simple pneumatic system operating on the hydrostatic principle. For reasons of interchangeability, the transmitters should be compatible with the pneumatic standard impulse of 3 - 15 psi.

5.12 Cleaning and Refining

The same conditions which were specified for pulper control systems also apply to the operation of beaters. The whole stock distribution and water-filling system in existing mills has been arranged on the basis of hand-operated shut-off valves, with special emphasis on a convenient and practical arrangement of these elements. The stock pump control is located centrally inside the beater room, within sight of all the machines. In spite of this simplicity, also in respect of manpower, a very efficient operation is ensured. The same also applies to continuous refining lines equipped with conical refiners. When large refining units such as disk refiners are employed, it is normally not possible to dispense with the control units which come along with the machines. However, the conical refiners of standard design are controlled by direct-mounted instruments. For refiners and

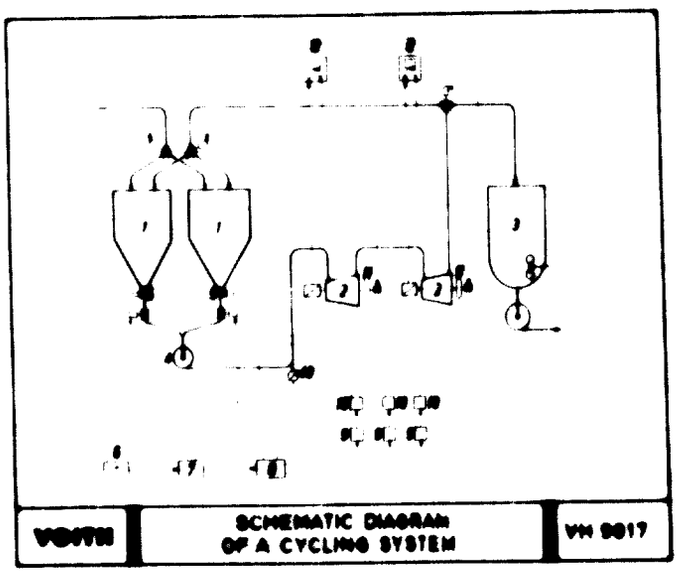
beaters, an ammeter or a KW-meter is in this case a very helpful instrument. It is only in the second place that thought will be given to fit the conical refiner with a pneumatic quick plug relieving unit, which should be connected with a non-flow reporting device. In its simplest form, this feature consists of pressure gauges mounted before and after the refiners, together with contactors. Needless to say, such a "mini" instrumentation must satisfy the technological requirements for the operation of a refiner system including the total stock volume. But it is not necessary to resort to specific flow-metering equipment. Good results have been achieved by the application of a hand valve with fixed flow characteristics; its pilot pressure is maintained constant by a direct-mounted pressure controller. This equipment offers excellent volume accuracy combined with control of high sensitivity. A diagram of this system is shown on picture 19.



No. 19

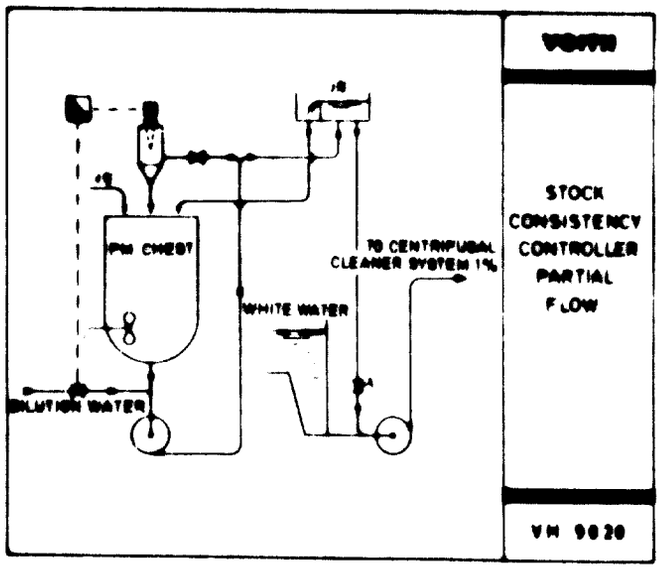
If recycling systems are planned instead of continuous refining lines, it is absolutely necessary to install the automatic control equipment needed to interlock the starters with the valve operators. The sequence of these cycles and operations cannot be mastered by manual control. Therefore, the selection of such a system requires well-defined pre-requisites, and its applicability has to be thoroughly investigated early in the planning stage.

The schematic of a recycling system is shown on picture 20.



No. 20

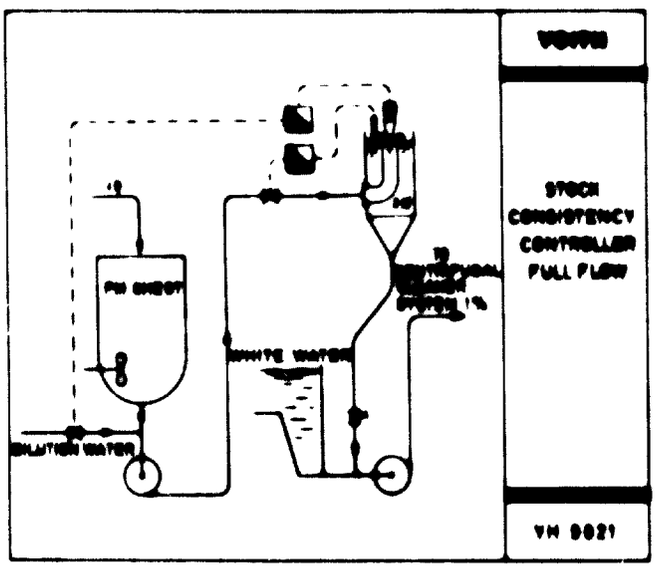
A measuring instrument which is a piece of standard equipment even in extremely simple systems is the consistency controller. This essential measurement cannot be readily replaced by simple makeshift equipment. Also the decision on the selection of the principle, i.e. partial-flow controller or total-flow controller, is not a matter which can be settled in a few minutes



No. 21

While the partial-flow controller, as per picture 21, provides good visual control of operation and clogging, it also holds drawbacks when high pump pressures are involved, so that ultimately the selection has to be made with consideration of the given

operating conditions, the service problem and the availability of replacement parts, not forgetting the ruggedness of the controller.



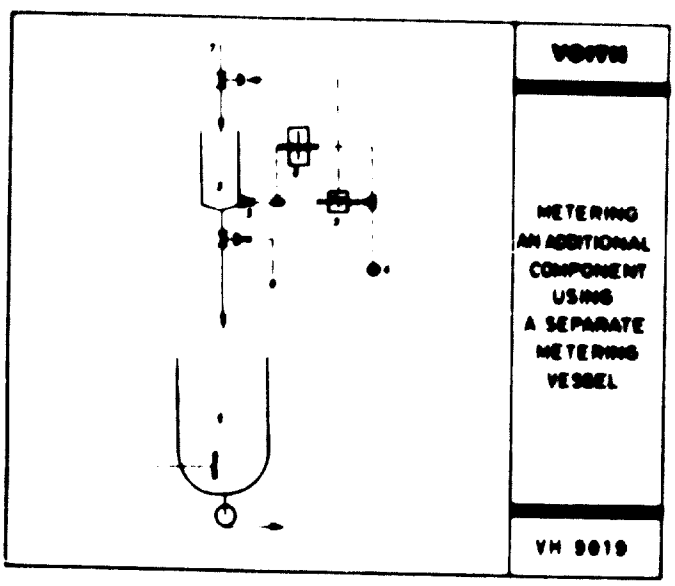
No. 22

In comparison with the partial flow, picture 22 shows a diagram using the full flow for consistency control.

5.13 Stock Blending

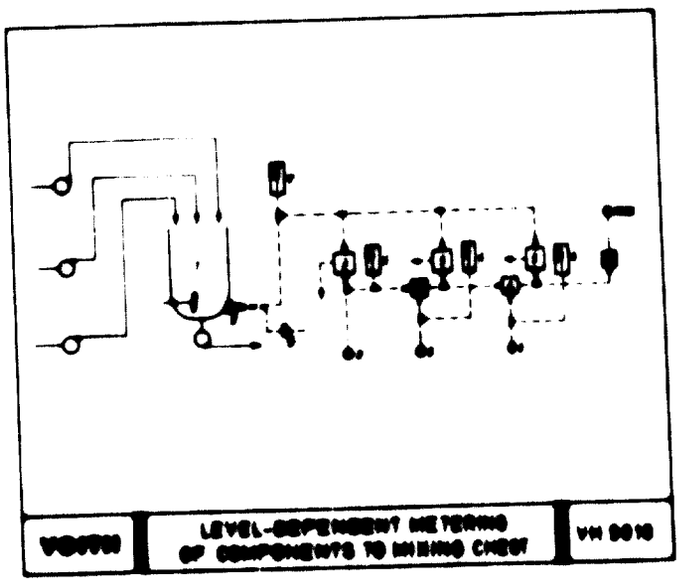
As far as stock blending is concerned, a distinction must generally be made between the batch system and the continuous system. Mixing chests for the batch system can be filled gradually with a metered volume of water and a graduated scale will be installed

accordingly. This, of course, also requires dependable personnel if rejects are to be avoided. To preclude this risk to the largest extent possible, measuring equipment can be built up from relatively simple means. This equipment also operates on the hydrostatic principle, using reference-value setters for flow pre-selection, the partial flows being successively added by a pump according to a fixed sequence. The set points are only accessible to one of the key people who is also in charge of setting these points. Additives are either metered under manual control or with the assistance of special metering vessels located above the mixing chest. Such simple vessels for manual metering, which do not require any special servicing, can also be handled by lesser skilled operators.



No. 23

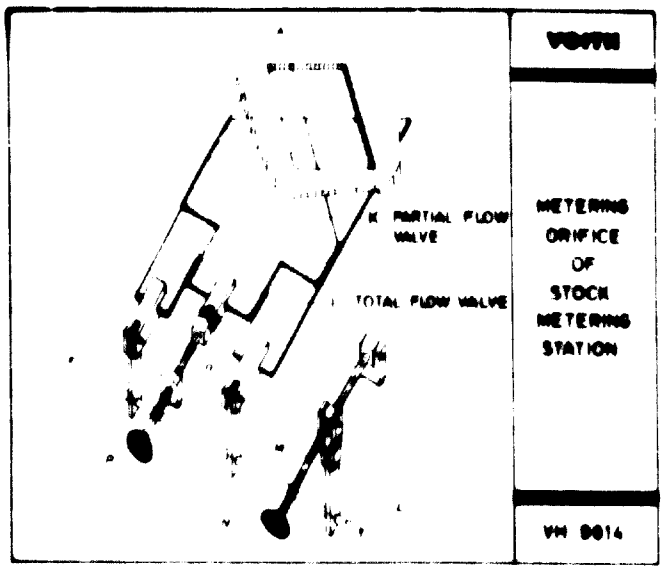
Picture 23 shows the diagram of metering one additional component to the stock using a separate metering vessel.



No. 24

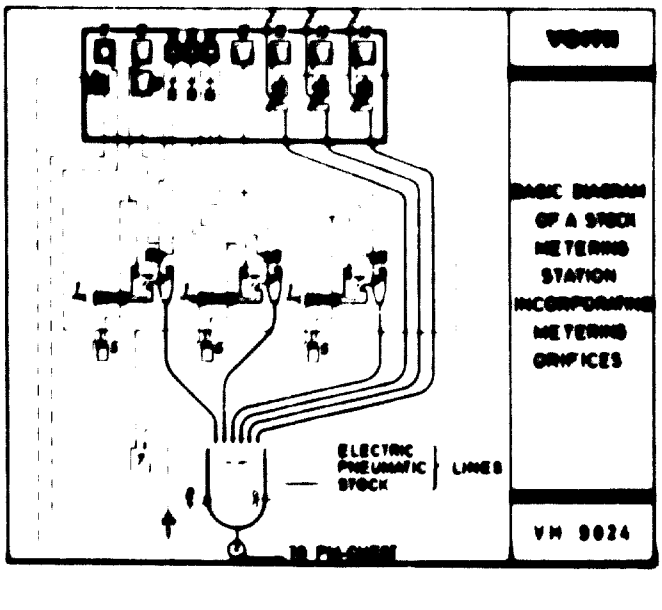
Picture 24 shows the level-dependent metering of several components to the mixing chest.

Continuous stock metering stations should not be equipped with magnetic flowmeters which in our countries are regarded as standard equipment for the flowmetering of fibre stock. Their dependability in operation demands a certain degree of maintenance. Specially suitable for operation in the countries under consideration are mechanically controlled orifice-type metering stations. A metering-type orifice is shown on picture 25.



No. 25

Available on the market in varying degrees of complexity and simplicity, these stations allow the mill to achieve excellent results. Component ratios or total flow rates can be varies solely by displacing the valve plates relative to one another. These systems can even be extended to a degree that at some later date they can be combined with modern pneumatic controllers. A system of this type is shown on picture 26.



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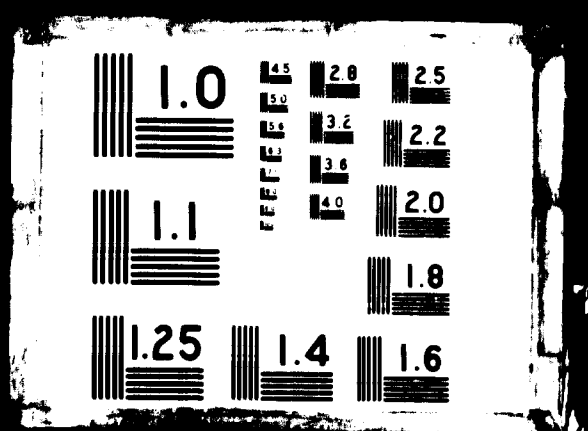


However, the metering of additives at very small rates requires the application of metering piston pumps which are coupled with the metering station either mechanically or electrically.

5.20 Paper Machines

At the paper machine itself it is strictly speaking only the headbox and the steam and condensate system which require process control equipment. An open headbox is usually equipped with a plain level controller. In case of a closed headbox the installation of a level and pressure control system, as used with the paper machines operating in Europe cannot be eliminated. It is hardly possible to adopt for headboxes compromise solutions which preclude the application of one controller or the other. These controllers are normally grouped together in a control console mounted close to the headbox. This console should also accommodate the associated controls such as remote control for stock regulating valves, coarse regulation bypass and necessary controls which result from the basic arrangement of the approach-flow system.

Another important point is the steam and condensate system. For machine speeds up to 400 m/min., the dryers are normally heated individually. All that needs to be provided is either one pressure controller for the whole dryer section or separate controllers for the pre-dryer and after-dryer sections as well as a

pressure controller for the felt dryers. It is good practice to have these controllers arranged for changeover of set points for operation and break, i.e. to equip these controllers with two separate set-point stations and a switch for manual change-over.

All other measuring points of the machine such as pressures and vacua may, in general, be indicated by direct mounted instruments which, of course, should be located in the vicinity of the hand-operated valves. The application of basis weight and moisture measuring equipment in mills as discussed is not recommended as the benefit of this equipment is out of any proportion to the problems which repeatedly arise.

In the countries under consideration, broke pulpers installed below the paper machine are also equipped with program control for automatic starting and automatic addition of water. It has frequently been found that, when started manually, such systems are not properly operated by the personnel, which is liable to cause trouble in operation. As before, manual-automatic switch is included.

Mechanically actuated float valves may frequently be used in the fresh-water and back-water circuits. Conditions permitting, the paper mills should not be reluctant to use this type of valve.

Valve performance is uncomplicated, repair if necessary can often be carried out with extremely simple means, and no special valve maintenance crews are needed.

6.0 Auxiliary Departments

6.1 Steam Generation

If steam is used only for paper drying and possibly to heat buildings, saturated steam with a pressure of 7 to 8 atmg. will be generated. In this case, the installation of a compact boiler unit is recommended. Picture 27 shows a cross section with the principle of a compact boiler.

No. 27

Picture 28 shows three units installed, of which one is a standby unit.

No. 28

The advantage of this type boiler is the compactness which is based on the special arrangement of the heat transfer surfaces. Space and construction cost savings compared to a flue boiler amount to about 35 %. There is no costly and high maintenance requiring masonary work necessary. Also the efficiency of this type boilers is high. The loss by radiation and convection is not more than 2 to 3 %. Its total efficiency depends on the kind of fuel and reaches 80 to 84 %. The erection cost of a compact boiler are very low for it is just put on two concrete blocks. Costly foundations are not necessary.

The compact boiler can be fired with oil, gas or coal. The feed-water treatment can be kept simple for the generation of low pressure saturated steam. This type of steam has low requirements for the water treatment compared to a boiler for over-heated steam feeding a steam turbine.

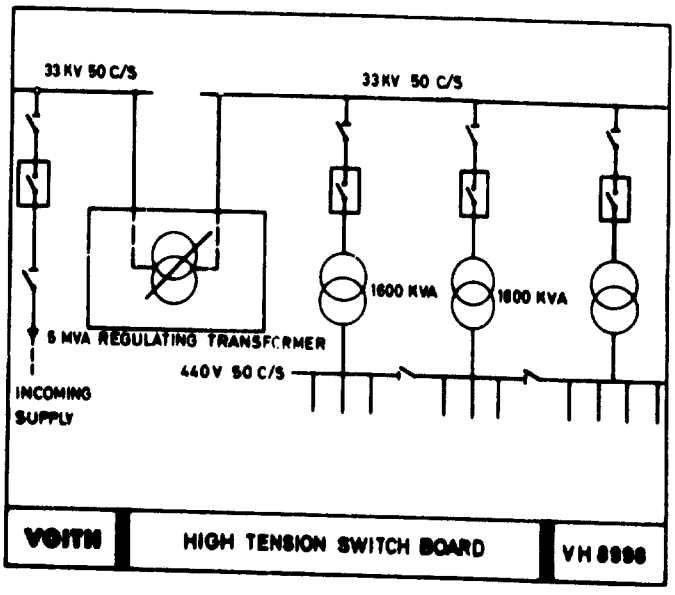
The condensate returning from the paper machine is reused. It has to be deaerated.

It is recommended to have a spare boiler with 50 to 100 %, of the continuous steam requirement.

6.2 Electricity Supply

The lowest installation cost of course arise if the electric energy can be drawn from the public electricity grid. If this is economical as from the operating cost, the electricity grid has to be checked for its suitability with respect to frequency and tension as well as rupture capacity.

Depending on the high tension, transformation is done in one or two steps. If the high tension is smaller than 10 KV transformation will be done in one step in case it is higher than 10 KV (33 KV) 2 steps are necessary. In small mills a low tension of 280 V is sufficient, because there are no big drive motors.



No. 29

Picture 29 shows the high tension switchboard as it was installed in a mill of a developing country. As you can see there is a regulating transformer installed to compensate tension instability in the electricity grid as it occurs quite frequently in these countries. With this arrangement it was possible to get the necessary stability for the paper machine drive. There is no electricity generated in this mill.

6.3 Process Water Supply

The quality of the paper mill process water depends on the product. The requirements increase with the following production sequence:

a) mill board, grey board, corrugating medium

b) Kraft paper, linerboard (unbleached)

c) writing and printing paper, Tissue (bleached)

The most common water supply is surface water from lakes and rivers. This water usually requires higher cost installations because of organic pollution and treatment after heavy rain storms and possible water from melting snow. Depending on the conditions the layout of the water treatment will provide for

a) mechanical treatment by screens and filters

b) sedimentation

c) sand filter; sometimes deferrization

6.4 Effluent Treatment

The cheapest way of disposing effluent is leading it into a lagoon. This method should be used if there is any possibility. Depending on local conditions effluent treatment can be very costly. In principle there are the same systems used as for the process water treatment. In some countries local laws may ask for the installation of a biological treatment plant.

If an effluent treatment plant cannot be avoided, rain and surface water should be drained separately from fibrous water and effluent

containing chemicals. In this case the size of an effluent treatment plant can be kept to a minimum.

7.0 Ancillary Equipment

7.1 Workshop and Spare Parts

If there is any possibility, repairs, especially for larger machine parts, should be done in a neighbourhood workshop. This would avoid the high investment cost for large machine tools, which would be idling most of the time.

In case however, the mill is in a remote area and has therefore to be self contained and cannot easily be supplied with spare parts, a sufficiently equipped workshop is a necessity. One of the biggest items will be the installation of a roll grinding machine. This machine could be equipped with an attachment for roll journal grinding thus possibly avoiding the purchase of a big and costly lathe. The tool sizes to be installed must be in accordance with the paper machine parts, super calendar, etc.

On top of higher machine tool investments for remote area mills the spare parts store has to be larger. There have to be spares for all vital items of the paper mill for approximately one year.

7.2 Laboratory

The paper mill laboratory is an item where a lot of money can be spent. Especially with starting a paper mill, and perhaps with a shortage of trained laboratory workers only a minimum laboratory should be installed.

There is little equipment required to test:

a) purchased pulp

b) finished product

c) water and fuel

These tests are only a fraction of those conducted in laboratories of big paper mills with the following departments:

a) air conditioned room for paper testing

b) physical laboratory

c) weighing and writing room

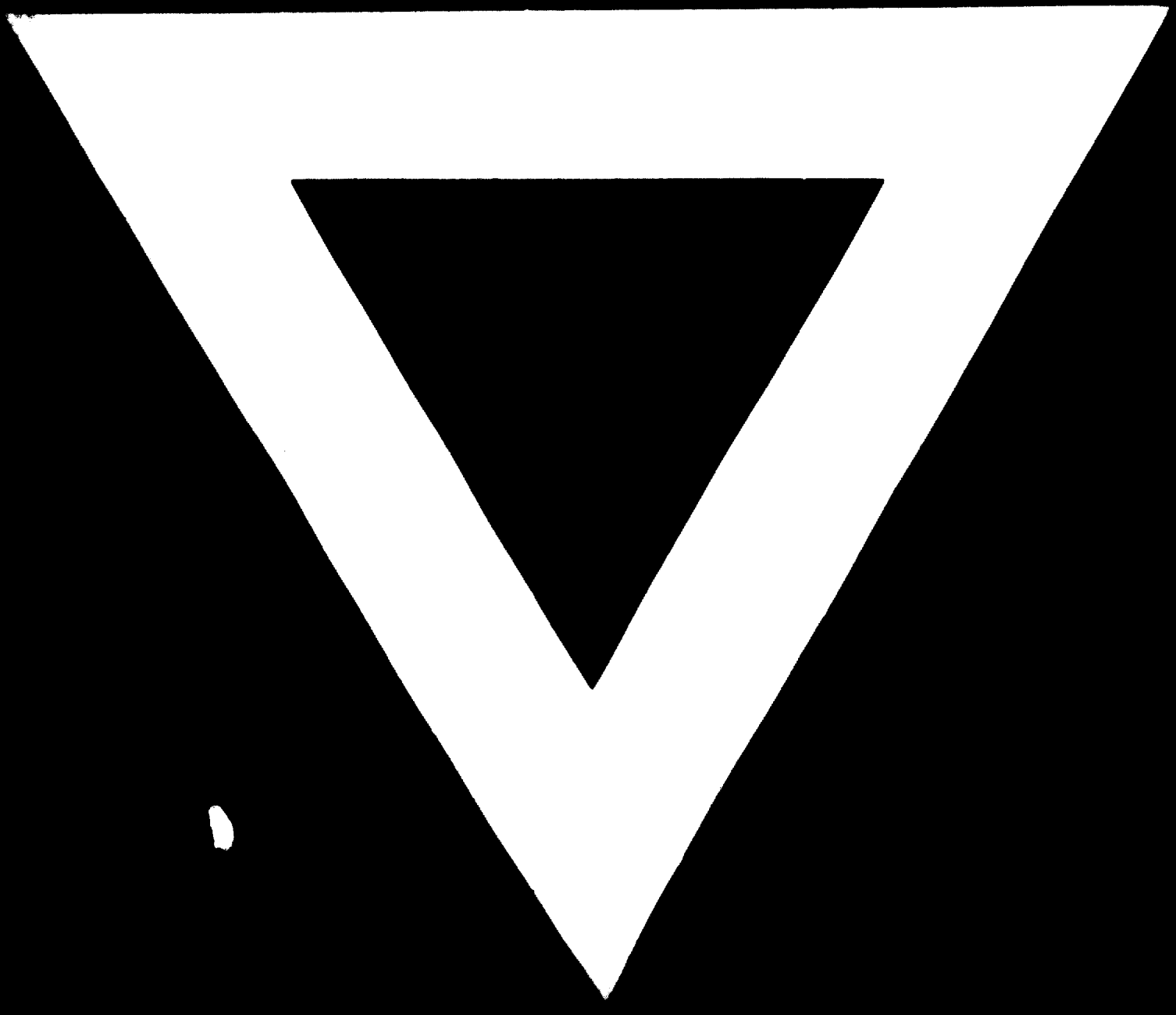
d) chemical laboratory

e) wet laboratory

f) store for chemicals and other laboratory equipment.

8.0 Conclusion

With the foregoing I hope to have given you a few general ideas on possible cost savings when planning a paper mill. As you will understand it is not possible to cover in a paper as this all aspects of how to build a low cost paper mill. Specific statements can only be made for a certain mill when all main points as products, output, raw materials, labour, location, climate, transportation and all other prevailing influences are known.



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