Some up-to-date Information on the use of Kamyr Equipment

Knut Dahl

The first subject to be covered is the use of the Kamyr two-vessel system.

This two-vessel system incorporating a separate high pressure impregnator is used in several pulp mills for the production of high yield kraft pulp. The purpose of the impregnator is to provide ideal impregnation conditions for the different chip fractions. This is of particular importance in high yield pulping in order to reach higher pulp yields at retained pulp characteristics and reject contents.

The principles of the system are illustrated in Fig 1. Kamyr standard equipment is used for steaming and feeding the chips to the top of the vertical down-flow impregnator. The retention time in the vessel is 15-40 minutes depending upon the impregnation demands, the pressure approximately 10 kg/sq. cm. and the impregnation temperature is 110 to 120°C. From the bottom of the vessel the chips are transferred to the inverted top separator of the digester The transport of chips from the impregnator to the digester is carried out by a liquor circulation. The impregnated chips and cooking liquor are heated with direct steam added at the top of the digester.

Knut Dahl, President Kamyr AB, Sweden.

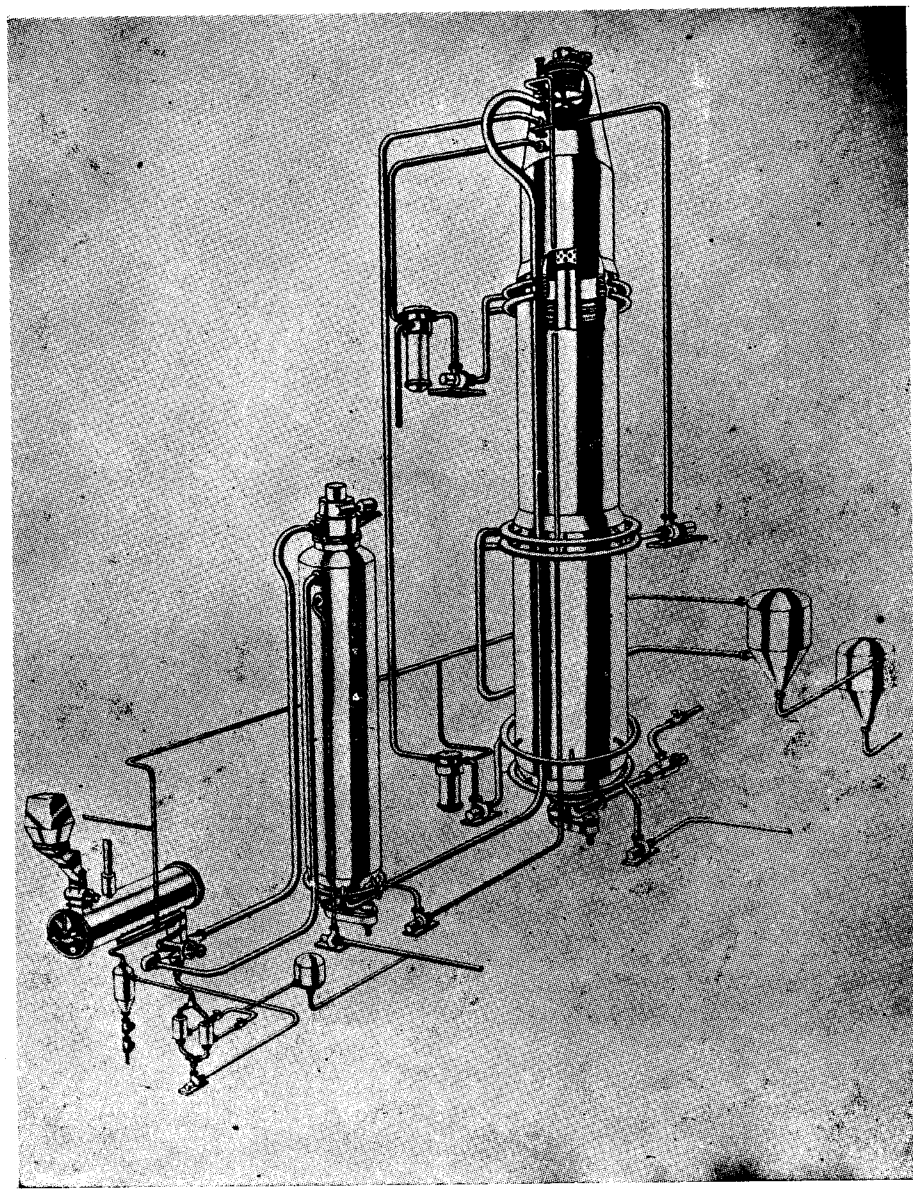

Fig. 1

This two—vessel system is also suitable for the many two—stage processes which are being developed. One of these is the polysulphide process which lately has gained great interest once more because special recovery systems are being worked out which will eliminate the drawbacks so far inherent with the use of big percentage of polysulphide sulphur charges.

The two-vessel system is installed in a great number of mills, amongst which is the M. Peterson & Son kraft pulp mill at Moss, Norway. Fig. 2. The digester is normally producing conventional kraft pulp in the Kappa number range 40 to 45 on softwood. The pulp is used for liner board and bag paper in an integrated paper mill. In June this year the digester was operated for two weeks with the polysulphide process. The polysulphide liquor was prepared by adding sulphur to white liquor. The addition of polysulphide sulphur was 1.5 percent on the wood The charge of white liquor was increased by 0.5 percent on the wood. but all other cooking conditions were kept unchanged in comparison to conventional kraft. The yield increase was approximately 3 percent on the wood. The runability and operating conditions of the paper machines were the same as for conventional kraft. The paper produced was slightly denser and had a slightly lower stretch, but other strength characteristics including tear were the same. M. Peterson & Son considers the paper produced on polysulphide pulp to be quite satisfactory from quality point of view. In view of the economical advantages with the polysulphide process, the mill therefore plans to operate the digester continuously on this cooking method from the beginning of next year.

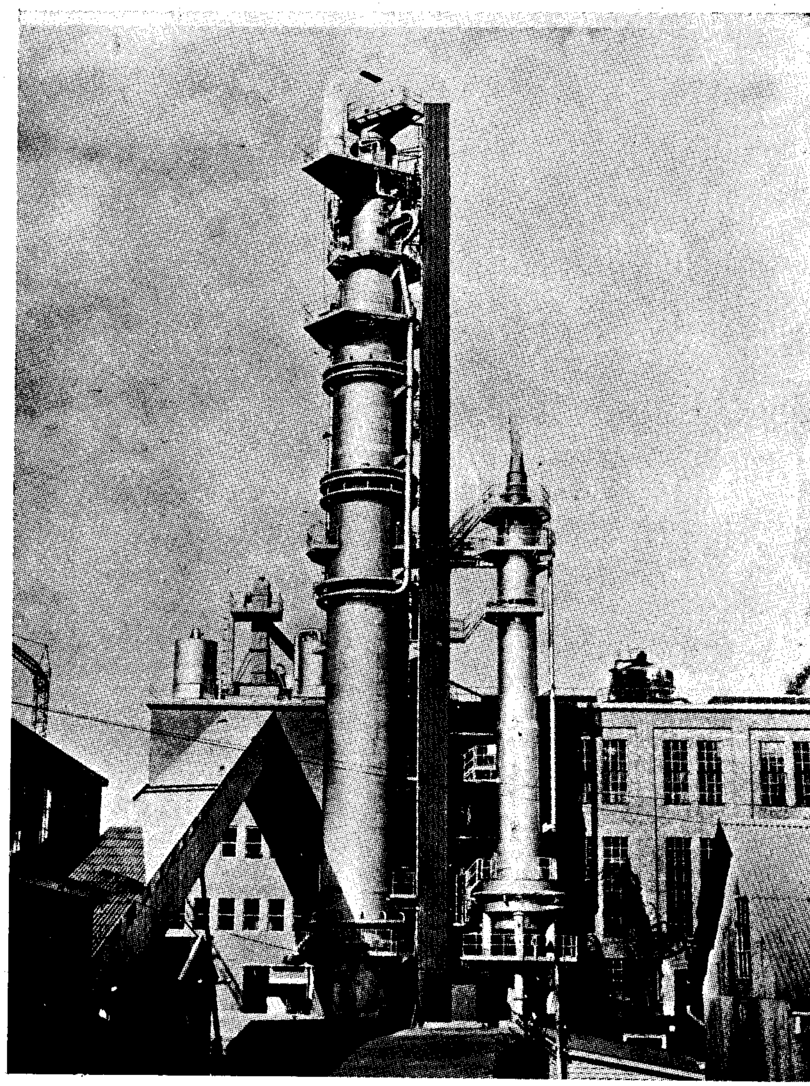

Fig 2

Fig. 3 is of interest as it shows how the mill is situated, namely really in the town which, of course, means that the odour from the mill is negligible.

The polysulphide system is only one of many existing and future processes which can be incorporated using a kamyr pressure preimpregnator. Such an impregnator would normally not be used for bleachable grade of pulps except possibly for woods which are extremely difficult to impregnate. On the other hand a later addition of a pressure impregnator to an existing digester when it is a wish to increase production of this degree to a degree which will considerably shorten cooking and washing times in the digester gives the Kamyr digester system an added flexibility. The impregnator can be installed during an annual shut-down.

Fig. 3

I have above mentioned impregnation as if this was a word with a clear definition which unfortunately it is not. The word is often used quite indiscriminately and in many cases what is called impregnation should not really be called by that name. A criterion of efficient impregnation is that it in actual operation really is carried out at a temperature considerably lower than cooking temperature and if it takes place under hydrostatic pressure like in Kamyr digesters for high quality pulps the effect is greatly increased.

As a development company Kamyr must not only develop completely new equipment but also modify existing Kamyr equipment to suit special demands of the customers.

One demand often made is the possibility to build or expand the digester department in two or more steps. Till now we have not been able to offer such a system and the customers with such plans could only consider a Kamyr unit for the total production from the beginning or a number of separate Kamyr lines. This of course, increased the initial investment and some customers did not choose our digester because of this higher investment even though they really wanted to install one because of the many operational advantages.

Today, however, we have designed a system which will make step-wise production increases possible and we can do so without using new equipment, just modify what is already existing, Fig.4. The feeding line will be built for the final production, but the digester proper is made for the initial capacity and further digester shells can be added later. The inverted top separator has just been moved outside and discharges into one or more vessels. It may seem suprising that this can mean much in cost, but it does. Not only because of the reduction in the cost of the delivered equipment, but also because of the reduction in erection costs.

Some of you may be so observant that they have noted the difference in the presteaming system as compared with our standard. what is shown is a feeding line with atmospheric presteaming instead of the usual horizontal steaming vessel. The presteaming efficiency is improved, the equipment cost and the building volume is considerably reduced, and the elimination of the low pressure feeder means the elimination of a maintenance item.

Switching between two different raw materials in a single digester is of great interest to many and how this is done in a Kamyr digester is described below. The description is based on the most difficult switching, namely between softwood and hardwood.

The raw material used, the different cooking conditions they need, will influence the delignification, and a lot of cooking parameters have to be changed.

For the two species two different alkali charges are used, chosen to get the best economical result and the best end product within the possible process limits. When you end up with two different alkali charges the amount of white liquor to the digester will change when you switch specie. As we normally add the alkali to the feeding system, the white liquor is changed at the same time as the new specie goes through the chip meter. We must then adjust other liquor flows to the digester top in order not to change the downflow in the digester too much during the specie change. As we have a large amount of free liquor

KAMYR MULTI-VESSEL DIGESTER WITH ATMOSPHERIC PRESTEAMING

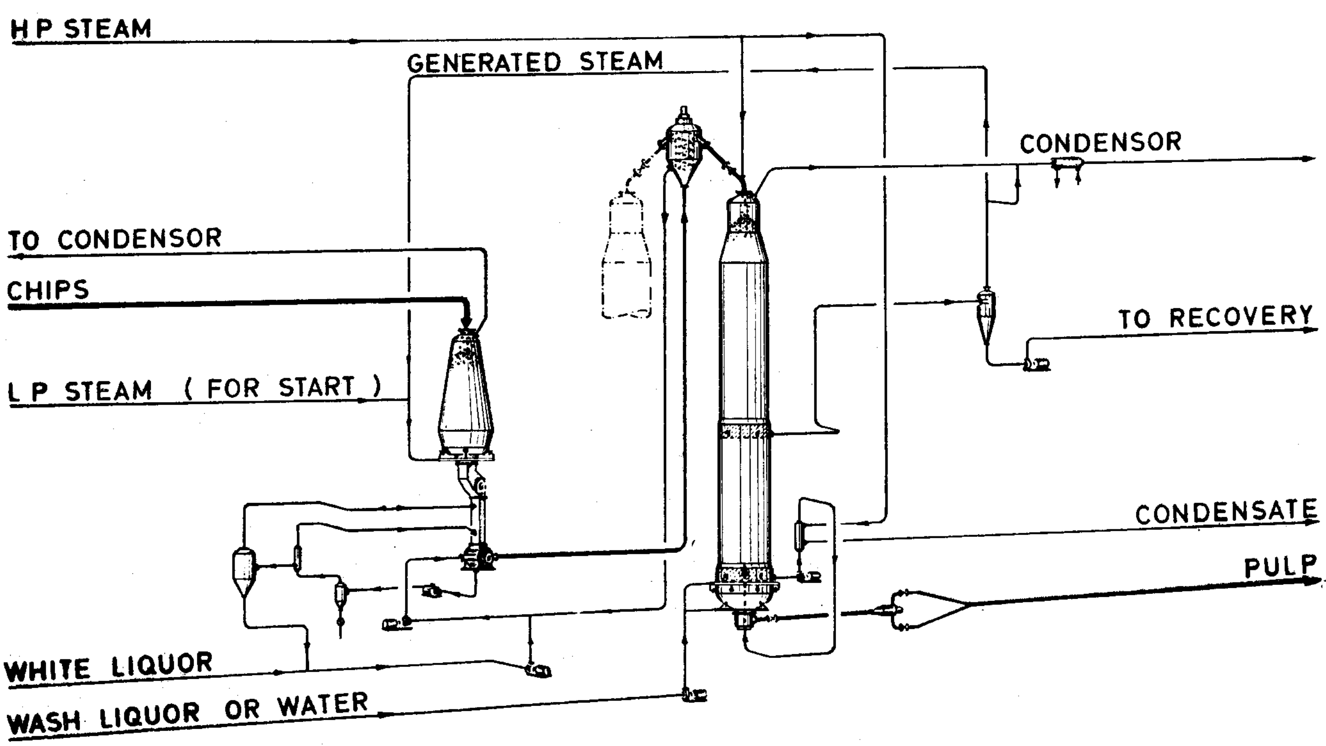

Fig. 4

in the digsster, we must also take steps to change the alkali concentration there sharply.

The retention time in the cooking zone is proportional with the production and the rpm of the chip meter at a constant Kappa number, wood specie, and degree of packing. The degree of packing in a zone of the digester is the ratio between the volume occupied by a specific amount of chips in the chip meter and the volume that this amount of chips occupies in the mentioned zone of the digester. The packing is different in the impregnation, cooking, and washing zones and it differs also with wood specie, degree of delignification, and the height of the digester. An example on different wood species is shown in fig. 5. The hardwood has about 10 percent higher degree of packing than softwood. With a specific weight of chips that may be 30 percent higher and a 10 percent higher yield the production of hardwood with the same retention time can be 50% higher than for softwood. This has to be taken into account when setting up a procedure for a specie change.

The temperature has to be set according to the specie, alkali charge, retention time, and the wanted kappa number. As you control the alkali charge and know the specie, the temperature is set according to the production with help of the H factor.

Theoretical example on change from softwood to hardwood

In fig. 6 is shown an example on a change from softwood to hardwood in a standard kraft digester. We have the following conditions :

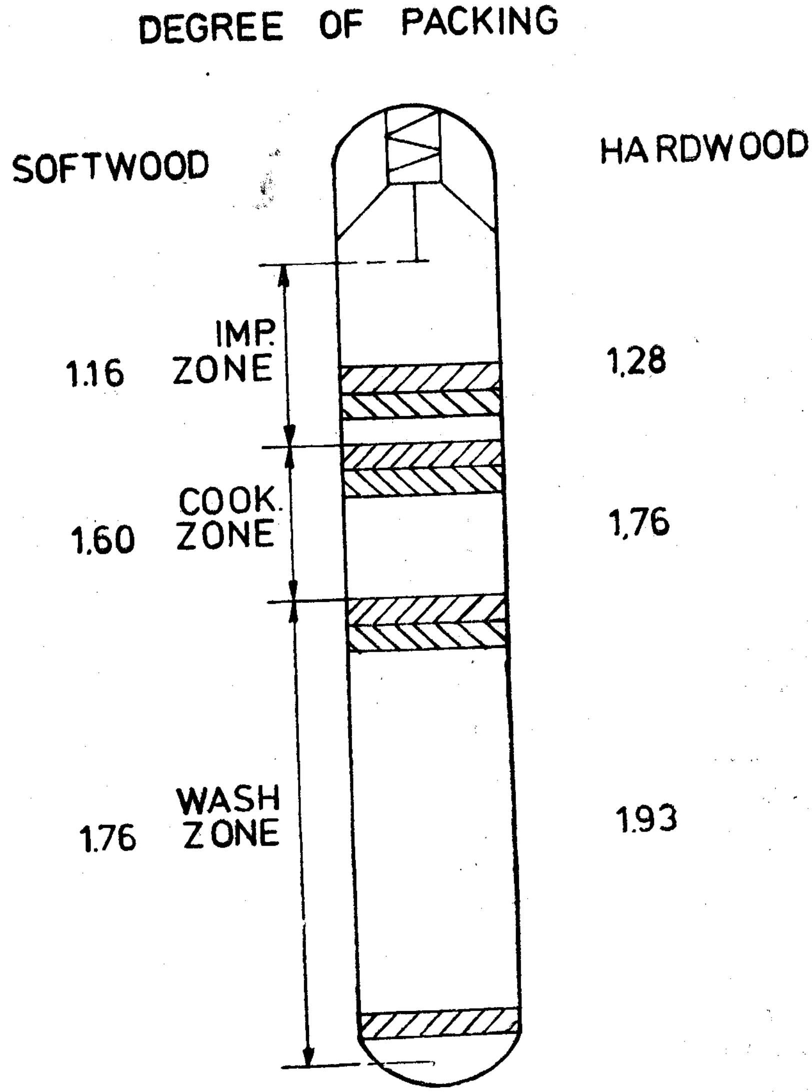

Fig. 5

	softwood	hardwood
Specific weight of Chips kg/m³ BD	145	185
A. A. charge, % B. D. wood NaOH	21	19.5
Yield, %	48	52.5
Production, t/24 hours	500	500
Chip meter, rpm	10	7.15
Degree of packing, impregnation zone	1.16	1.28
Degree of packing, cooking zone	1.60	1.76
Degree of packing, washing zone	1.76	1.93

With the present softwood production the retention times are: 1 hour for impregnation, 1 hour for cooking, and 2 hours for washing. We want to have the new specie coming out at time T_4, and with the present speed we have to start feeding the new chip specie at time T_1. As we know that the hardwood has a 10 percent higher degree of packing, we have to increase the chip meter speed by 10 percent, as the new chips start filling up the impregnation zone, to get a constant speed of the chip column and a constant retention time. At the same time as the hardwood chips first go through the chip meter the A. A. charge is also changed.

After 1 hour the interface has moved down to the cooking zone and the cooking temperature is changed, according to the new specie and chip meter rpm. The production of softwood is all the time 500 t/24 hours. The production of hardwood coming down the digester is: 500 t/24 hours+10 percent higher chip meter rpm+27.5 percent higher specific weight of chips+9.5 percent higher yield equal to 770 t/24 hours. The production will in most cases be so high that the following departments cannot take it, and we have to do a rpm rate change.

When we change the rate of production, the chip column will change speed and the cooking time will be changed in the same proportion. The chips that are just leaving the cooking zone when we change rate, will have a cooking time proportional to the old chip meter rpm, and the chips just entering the cooking zone will get a cooking time proportional to the new rpm. The chips that are in the cooking zone will get a cooking time between those two.

To get the same amount of heat into all chips the cooking temperature has to be changed in small steps over a time equal to the cooking time before the rpm change.

As we can see from Figure 6 it is very suitable to do the rpm change at the same time as the specie change comes out of the digester.

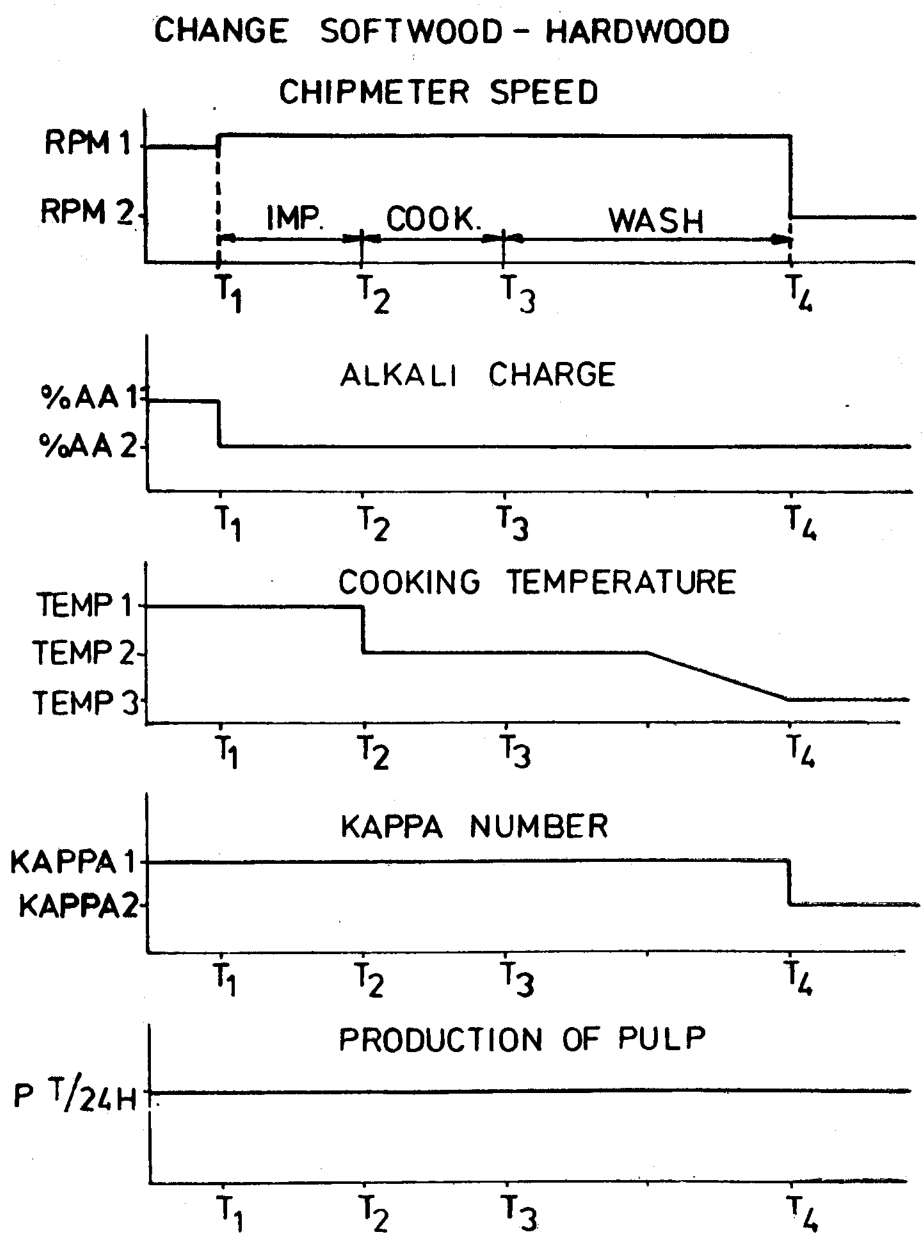

Fig. 6

The cooking temperature for the hardwood is set for a production of 770 t/24 hours and if we want to keep a constant production of 500 t/24 hours out of the digester, we should start changing the temperature 1 hour before the interface is coming to the bottom of the digester. When the interface is coming out, we can change the rpm of the chip meter according to 500 t/24 hours of hardwood pulp. When the interface passes the washing zone, the extraction should be increased to get an upflow in the washing zone corresponding to 770 t/ 24 hours of hard wood.

Now over to bleaching and first some words on oxygen bleaching. So much detailed information has lately been printed and presented in conferences that I will only touch on what I consider the major point.

Fig. 7 shows in words the equipment steps in oxygen delignification (a better word than bleaching) and each step can actually be considered quite separately,

O_2 - BLEACHING

↓

THICKENING TO HIGH CONSISTENCY

↓

FEEDING AGAINST HIGH PRESSURE

↓

REACTOR

↓

WASHING

Fig. 7

The first step of increasing the consistency can be carried out by different means, for instance by a special drum thickener or by one type or other of presses giving higher consistencies.

Nor is the second step, feeding the reactor, directly connected with the success of the process proper.

The reactor design, however, is in our opinion the key to the efficiency of the process and decides how far the delignification can be carried out in the O_2-stage. The firms L' Air Liquide, France, SAPPI, South African and Kamyr developed a reactor design which we believe will allow the highest possible delignification without harm to the pulp quality and obviously the aim of the O_2-stage must be to eliminate completely the chlorination and the first NaOH stage in the subsequent bleach plant.

The design is shown in fig. 8 The pulp falls from fluffer through a rotating chute on to the first of a number of rotating trays. Sectors are formed above the trays by stationary walls attached to the reactor wall. The pulp remains stationary, while the trays rotate and each tray has a cut-out corresponding to one sector. Each time this cut-out passes below a sector filled with pulp this pulp drops down on the tray below and the empty sector is again filled with pulp by the rotating chute. This continues from tray to tray and obviously the cut out on each tray is staggered in relation to the others.

It is difficult to make a simple description, but this does not mean that the system is complicated.

Our opinion is that this design will:

- ensure close control of the retention time
- ensure that channelling will not occur
- ensure ready access of O_2
- allow close check on the process through sample points above each tray

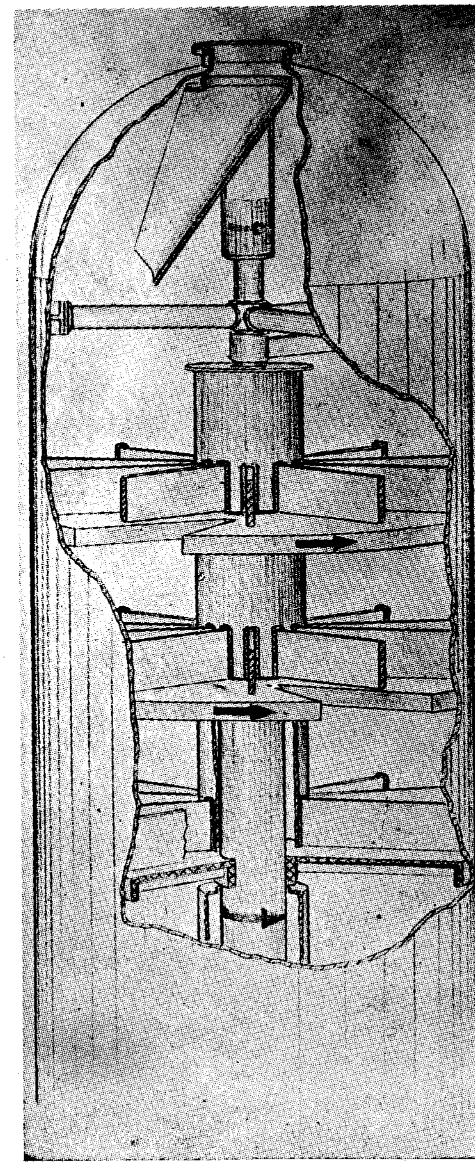

Fig. 8

- counteract variations of ingoing consistency which may occur
- ensure minimum blend on changeovers when switching grade or raw material.

The larger the reactor, the more important these points will be.

The final stage, namely washing of the pulp after the oxygen treatment, is also not directly connected with the process and with the type of reactor. The only thing that is certain is that the washing must be very efficient in view of the caustic or white liquor added to the oxygen stage. One stage of washing is certainly not sufficient.

Today there are two commercial O_2 -reactors in operation, namely the one in south Africa of the design described above which has operated for more than two years, and the second one a unit just started up a month ago in Gruvöns Bruk, Sweden. This Kamyr reactor is quite different from the one described above. It is shown in Fig. 9 and was originally a Kamyr reactor specially built as a high-consistency, high-pressure soda stage for a dissolving pulp bleaching plant in one of Billeruds AB sweden mills. When this mill was closed down, Gruvöns Bruk decided to move the reactor and use it as an O_2-stage. This reactor is the simplest and least expensive of all as the only piece of equipment included is a standard Kamyr bottom scraper. It will certainly be very interesting to follow the results from this reactor. The unit has started with a production of 250 tons of softwood pulp to be increased to 500 tons and eventually they hope for 700 tons.

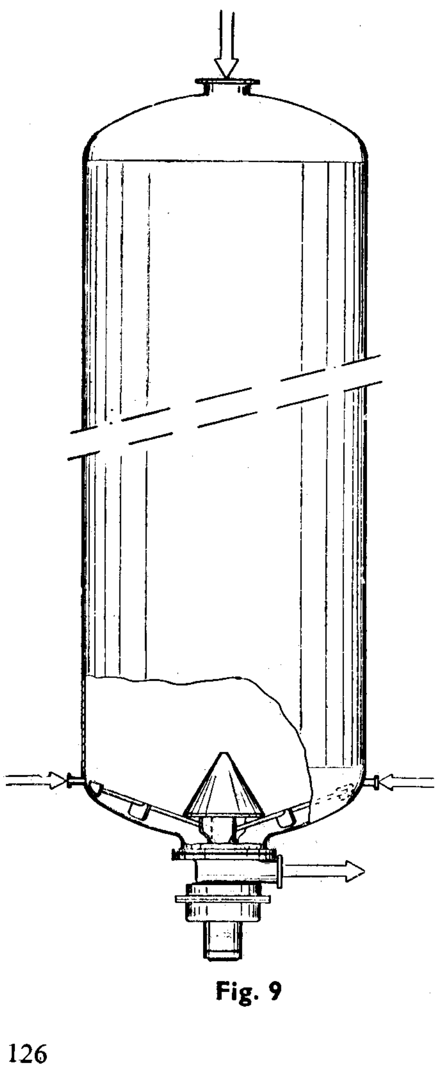

Fig. 9

I should mention that the next Kamyr reactor with trays will be started up in France in May–June 1973 with a production of 550 tons of hardwood pulp.

Then a few words on the Kamyr pilot plant for displacement bleaching.

We have never hidden that we have had many difficulties during our development of diffuser bleach plants. The brown stock washing diffusers have not been a problem, but the bleach diffusers definitely so. It started with capacity problems, continued with corrosion problems in the ClO_2 diffusers, and when these were solved came the problem of corrosion in the Cl_2 diffuser which is still there, although we have a design now in operation which may be the answer to the difficulties. We have kept on fighting, however, and mainly because we know that the bleaching diffuser could lead to a completely new mechanical concept of a bleach plant.

It was first conceived by Prof. Rapson of Canada that when bleaching chemicals are displaced through a pulp mat, considerably faster reaction rates can be maintained than presently in conventional processes, where the bleaching chemicals are "stationary" in relation to pulp, and work by International Paper Co., U.S A., has confirmed Prof. Rapson's theories. Based on present experience it is felt that the high reaction rates are due to the continuous exposure of the fibres to highly concentrated active chemicals, throughout the whole displacement operation. If the extracted liquids can be highly recirculated after make-up with new bleaching chemicals, the requirement of complete or close to complete conversion of the chemicals in a single pass becomes obsolete and still higher concentrations of active chemicals can be maintained.

When studying the possibilities to develop a commerci l process based on these principles it becomes evident that the prerequisites for success are that :

—the process should be based on the concept of a cross current reactor where a multitude of consecutive liquid displacements can be performed crosscurrently to the same continuous flow of pulp.

—the uniformity of the displacement front passing through the pulp mat must be satisfactory.

—the degree of recirculation of eluates should be high (preferably 80–95 percent).

—the quality of the resulting product must be comparable or superior to conventionally manufactured pulps.

During a study with a small pilot diffuser plant (12 ADT/day) it was shown that all the basic prerequisites can be met in a technical continously operated process. Birch kraft pulp, prebleached with the sequence C-E-H was successfully bleached further in two stages with the sequence D-E without intermediary water wash between the stages, with reaction rates that were more than 30 times higher than conventionally required. The uniformity of the displacement front is demonstrated in fig 10 (coloured slides but not printed as it will not show well in black and white).

Based on this positive experience Kamyr decided to carry through a 1 million Dollar development project including both laboratory testing and tests with a new pilot plant with a nominal capacity of 60 ADT/day and provisions to increase the capacity up to 120 ADT/day. The project was started in September 1971 and the pilot plant started up in March 1972.

The laboratory data clearly show that it is possible to produce high quality fully bleached market pulp with this multistage process without intermediary water wash between the stages, with a considerably lower consumption of bleaching chemicals than conventionally required.

The pilot plant operates with chlorinated birch kraft pulp, and the work is divided in three phases so that phase I includes production of semibleached pulp (brightness 70–75°SCAN) with the sequence C–E–H, phase II includes four stage bleaching up to 85°SCAN and phase III to full brightness (90°SCAN).

The phase I will be completed within October this year. The results so far are very promising We have been able to produce good market quality semibleached pulp on a continuous basis on line, thus by-passing the E and H stages of the mill and producing a stronger pulp with less chemical consumption compared to the normal mill pulp. The effluent amounts from the stages are less than one ton per ton of pulp per stage.

The present work is mainly concentrated on refinement of details until the end of October when the plant will be converted into a four stage unit.

The start-up of phase II is scheduled to the first half of Decmber.

The positive experience so far gives us ample reason to believe that the new displacement bleaching process will have the following benefits over the conventional tower bleaching :

—less equipment

—lower power demand

—lower chemical consumption

—considerably less effluent

Fig 11 shows a three Stage displacement bleaching tower for D–E–D with the flow relationship indicated. Reaction times are approximately 6 minutes per stage.

May I end my paper with a slide showing what I believe is close to what a fibre line of the not too distant future will look like, fig. 12.

A Kamyr digester with or without preimpregenation, depending upon raw material and final product, the "Hi-Heat" washing which will be

KAMYR DISPLACEMENT BLEACHING

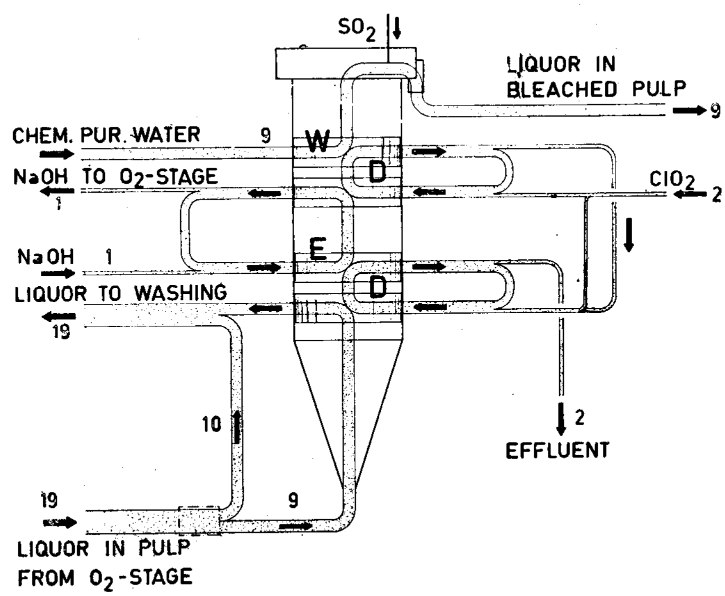

Fig. 11

more important than ever followed by in-line refining (as I expect that for all end products the Kamma number from the digester to be high), then oxygen delignification (directly attached to the digester), no screening, final displacement bleaching in one tower.

I believe the concept not too far away from realization and every one with a Kamyr digester will have the possibility to modify to fit this concept.

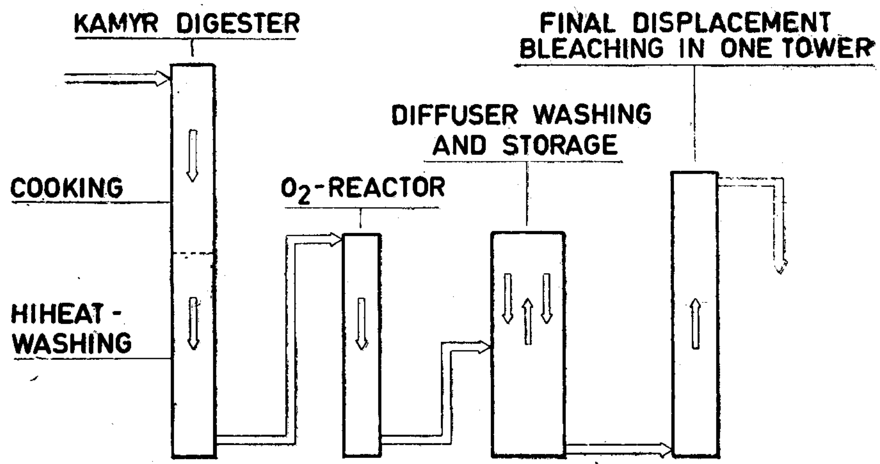

Fig. 12