Wood and Non-Wood Fiberlines - a Modern Approach

Bokstrom M. , Germgard U.

ABSTRACT

Modern pulping and bleaching process equipment is more efficient and less polluting and energy-consuming than the traditional process equipment which is still used in many pulp mills in all countries today. Thus, investments in modern process equipment involve a number of benefits, which also include savings in steam and power demand as well as increased production capacity. These benefits are very obvious for non-wood pulp production, which is shown more in detail in the paper. A special Sunds Defibrator fiberline concept for bleached non-wood pulp is presented, where the recommended bleaching sequence is of TCF-type.

INTRODUCTION

The focus of Sunds Defibrator has always been the fiberline, from woodhandling to pulp drying. For many years, developments at Sunds Defibrator have been guided by the "Precautionary Principle", Which states that the ideal situation is one in which no effluents with unknown environmental consequences shall be permitted. We have concentrated our efforts in technology development on producing machines and technologies which move the industry closer to ideal.

It is ofcourse necessary to produce environmentally acceptable equipment and services that are useful and affordable. This tension between the ideal and the cost effective has been a positive driving force constantly pushing us to get better performance from our machines and processes. Sunds Defibrator has developed a fiberline that:

- can meet the environmental targets
- can produce high-quality pulps
- is flexible, for example ECF or TCF pulp can be produced using the same equipment
- can handle large production in a single line
- uses the same type of washer in all positions
- uses the same screens in fine screening and rescreening

Examples of its full and partial applications for wood and annual plant pulp production are presented in this paper. We concentrate on the fiberline from cooking to bleaching.

Sunds Defibrator, SE-851 94 Sundsvall, Sweden.

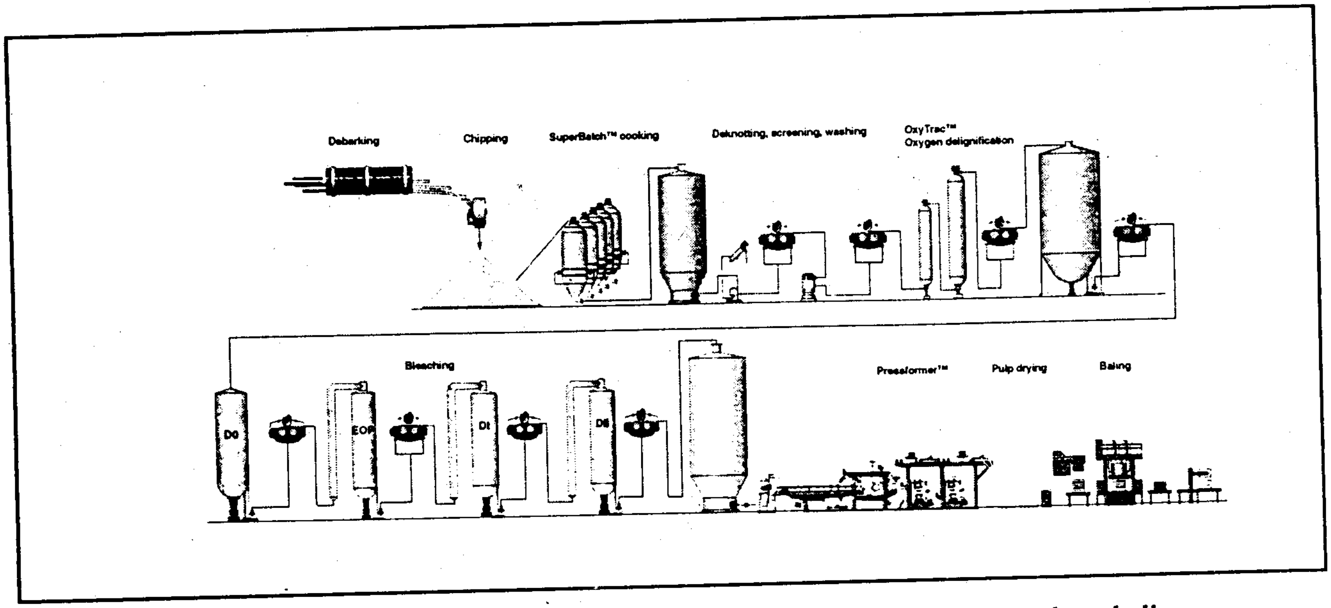

Figure 1. The Sunds Defibrator Wood Pulp Fiberline from wood yard to baling.

A MODERN FIBERLINE FOR WOOD PULP PRODUCTION

A modern Sunds Defibrator fiberline for wood-based production of ECF-bleached pulp is shown in figure 1.

The fiberline consists of wood handling, SuperBatch™ cooking, deknotting, screening, oxygen delignification followed by bleaching, pulp drying and baling. As can be seen, TwinRoll™ presses are used in all washing positions. The use of the same type of washer throughout the plant simplifies operation and maintenance and reduces spare part costs. The cooking plant can easily be adapted to new production levels just by adding digesters.

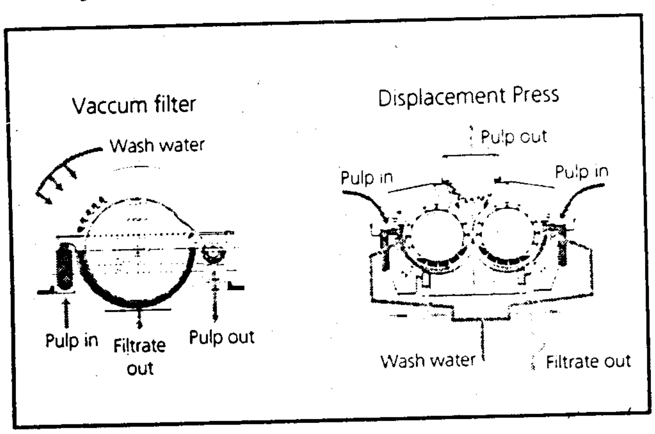

Figure 2. A simplified description of the washing principles of a vacuum filter is shown to the left and of a displacement press to the right.

PRESSES IN THE BLEACH PLANT

The principal difference between a filter washer and a displacement press is shown in figure 2. In the filter case a very diluted pulp slurry (1%) is pumped to the filter vat where it is dewatered on the surface of the drum. The pulp fibers are thus picked up on the filter drum and transported through the filter shower section, where a further washing takes place with 9-12 m^3 water/t. After dewatering on the remaining part of the filter drum to about 10-14% consistency the pulp is leaving the filter for the next bleaching stage. In the displacement press the pulp is instead fed from two opposite directions at 3-4% cosistency in the DPA-press or 6-7% consistency in the modern DPB-press. The pulp is first dewatered on the press roll. Wash water, about 4 m^3/t, is then added to the pulp in the displacement zone. The pulp is finally pressed between two counter-rotating dewatering rolls to a consistency of 30-32% and altogether this leads to a very efficient wash. The mechanical forces on the pulp during pressing in a Sunds Defibrator press has no negative influence on the pulp properties which has been shown in special tests and indirectly by the large amount of presses sold to the pulp mills.

There are two different types of presses available for chemical pulps, i.e. the displacement presses (DPA or DPB) and the cheaper dewatering press(DWA), where no wash water is added to the press as there is no displacement zone, Figure 3. The "wash" is in the latter case obtained by dewatering and then pressing the pulp to a high consistency, which

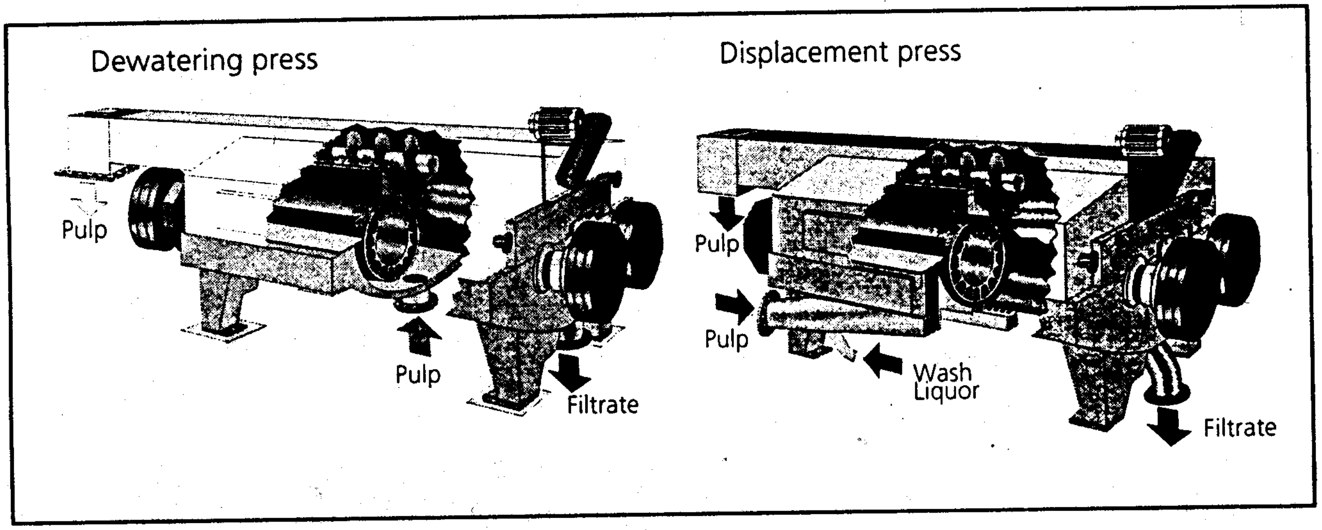

Figure 3. A simplified drawing of a dewatering press is shown to the left and a displacement press to the right.

separates the fibers from the major fraction of dissolved organic material. However, dilution water can be added to the pulp slurry prior to the press and good pulp washing efficiency is therefore obtained in the dewatering press as well. The actual pulp consistencies used in presses and as a comparison in a vacuum filter are shown in table 1.

Tabel 1. Pulp consistencies used in vacuum filter and in presses

	Pulp conc. in %	Pulp conc. out %
Vacuum filter	1.0-1.5	10-14
Dewatering press (DWA)	3-5	32-35
Displacement press (DPA)	3-5	30-32
Displacement press (DPB)	6-7	30-32

In figure 4 we compare a press and a vacuum filter with respect to wash efficiency, i.e. COD-removal, and water consumption. The wash water addition to a press is usually only about 4 m^3/t, which corresponds to a dilution factor of 2 m^3/t. Using the same dilution factor on a traditional filter means that about 9 m^3 of wash water per ton of pulp is needed, and still the vacuum filter is an inferior washer as is seen here. Due to the high pulp consistency after the press, a very small volume of water is carried over to the next stage. The press, therefore, serves as an efficient barrier between the stages.

All presses are significantly better pulp washers than filters, which is shown in a simplified way based on COD in table 2. Thus, only 15-25% of the COD is carried over to the next stage after a press while 35% is left in the pulp after the filter. A press is therefore a very competitive pulp washer in a modern bleach plant.

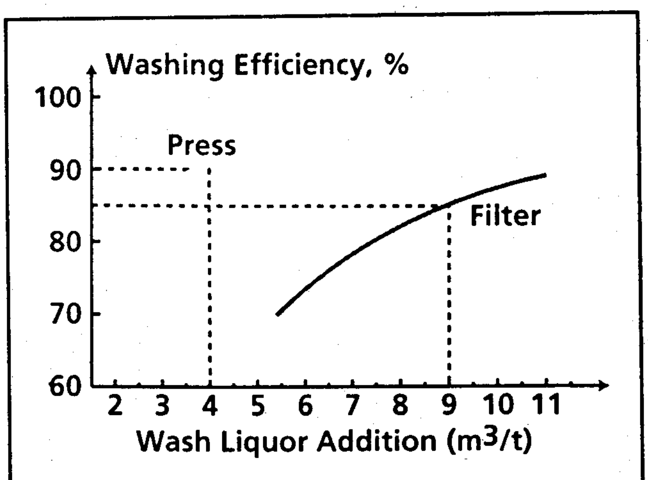

Figure 4. The COD-washing efficiency of a press and a filter versus wash water addtion.

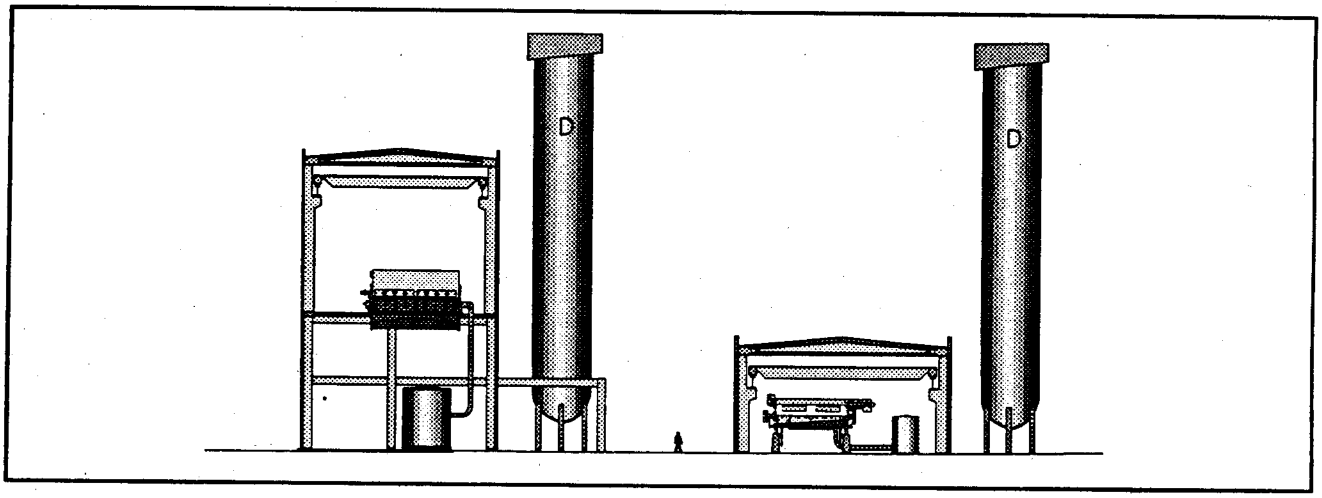

Figure 5. A filter-based bleach plant requires a considerably larger building than a press-based bleach plant.

Table 2. Approximate washing efficiencies of different types of pulp washers.

Wash equipment	Washing efficiency (COD)
Vacuum Filter	65%
Dewatering Press. (DWA)	70-75%
Displacement Presses (DPA/B)	85%

Compared with a filter, a press is a more expensive machine and this explains why presses were earlier never used in bleach plants. However, there are several indirect cost items that are lower when using a press. Lower building costs and smaller filtrate tanks are the most obvious examples. The reason for the lower building volume is that no drop leg is needed in a press and that the space required above and around the press for maintenance and other purposes is smaller. The modest filtrate tanks are a result of the lower pressate volumes per ton of pulp in a press. altogether this means that the building a volume neeeded for a press-based bleach plant can be reduced by 55-60% compared with that of the filter, figure 5. The total cost for the press alternative is therefore similar to, or in some cases even lower than, the corresponding cost for a filter-based bleach plant while at the same time the washing efficiency is improved.

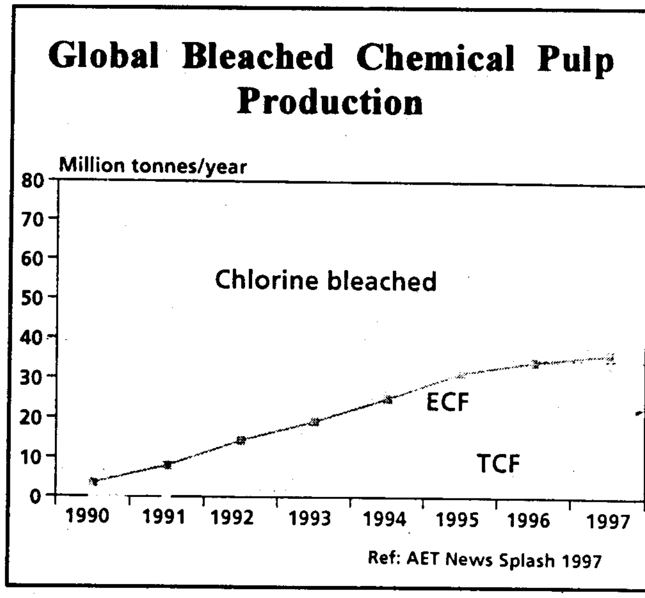

Figure 6. The global production of bleach pulp divided into three different groups depending on the way the pulp is bleached.

ENVIRONMENTAL CONSIDERATIONS

Due to stricter environmental demands in most countries chlorine bleaching is being phased out and replaced by either chlorine dioxide bleaching (ECF) or totally chlorine-free bleaching (TCF). This can be seen in figure 6, where the production of bleached pulp according to three different principles is compared during the years 1990-1997. It shows that bleaching with chlorine gas is steadily decreasing, while modern bleach plants tend to be of ECF- and to a lower extent of TCF-type. Modern ECF-sequences have such a low polluting load that they are comparable to TCF-bleaching and many pulp mills therefore prefer ECF-bleaching, as this type of bleaching is well known to the industry. However, if bleach plant filtrates are to be recycled to the chemical revovery system, this will be easier with a bleach plant of TCF-type.

One key issue in the efforts to close up a pulp mill is to reduce the water consumption, as this directly affects the water emissions. The development in recent years for bleach plants is shown in figure 7. From the old case, to the left in the figure, where filters were used, the water consumption was 50-100 m³/t and in some cases even higher. Development has since then moved to the right in the figure, and today the most modern bleach plants are emitting only about 5 m³/t. This volume can perhaps be further reduced as is indicated in the figure. However, in such a very tightly closed mill it will be hard to avoid both increased consumption of bleaching chemicals, due to carry-over between stages, as well as increased risk of scaling.

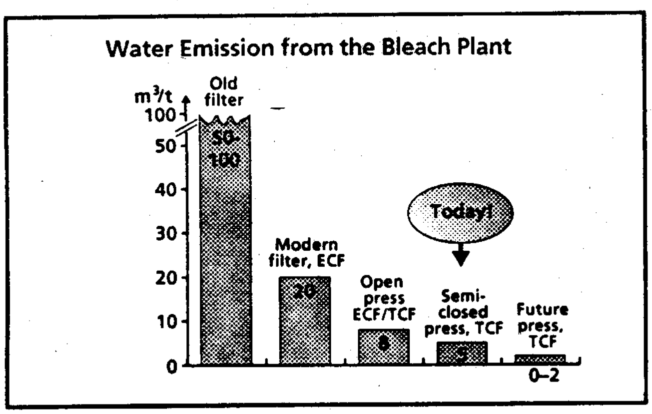

Figure 7. The water emissions from bleach plants are steadily decreasing.

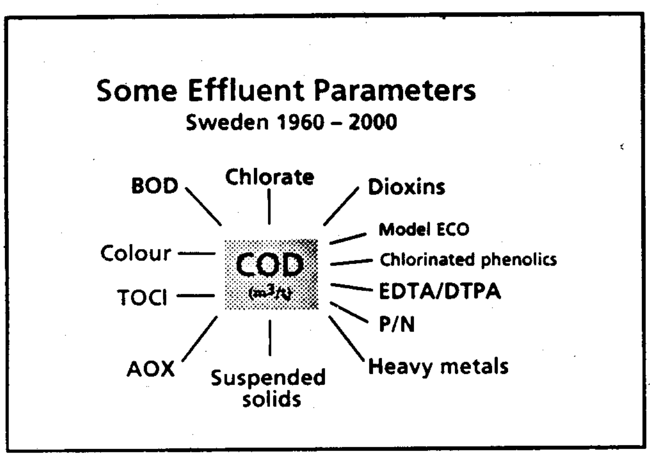

Figure 8. Some effluent parameters used in Sweden between 1960 and 2000

A number of effluent parameters have been used over the years and some of the more common ones are shown in figure 8, which in a simplified way summarizes the parameters used in Sweden between 1960 and 2000. The parameter COD is the dominating analysis for assessment of the pollution load and all Swedish pulp mills have got pollution restrictions expressed as COD-values.

There has been a tremendous reduction in COD—load from the Swedish pulp mills since 1960, figure 9. At that time the COD-emission was about 500 kg/t while today the mills are emitting about 30-50 kg/t. In the next few years it will be further reduced to about 15 kg/t, analyzed after external effluent treatment. One of the Soda kraft pulp mills has even declared to be below 10 kg/t at the same time.

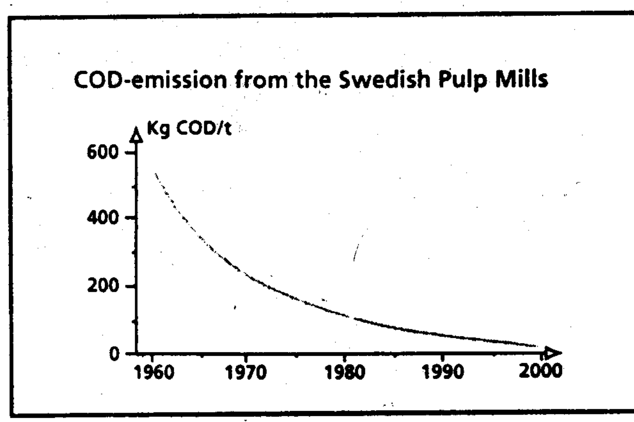

Figure 9. The COD-emission per ton of pulp from the Swedish pulp mills have steadily decreased since 1960.

EXAMPLES OF FIBERLINES FOR HARDWOOD PULP PRODUCTION

Advance Agro, Thailand, was our first totally press-based fiberline. It was started up in January 1996 and it produces fully bleached Eucalyptus Camaldulensis pulp with a design production of 560 ADT/d, figure 10.

The start-up of the greenfield project was successful and within less than one year the production was more than 10% above design capacity. There were many reasons for that, but most important was the ease to operate the equipment and its ability to accept quite large variations in raw material. The SuperBatch™ cooking plant accepted large variations in chip quality, depending on very thin logs, without any operational problems and was still producing an excellent pulp which is easy to bleach.

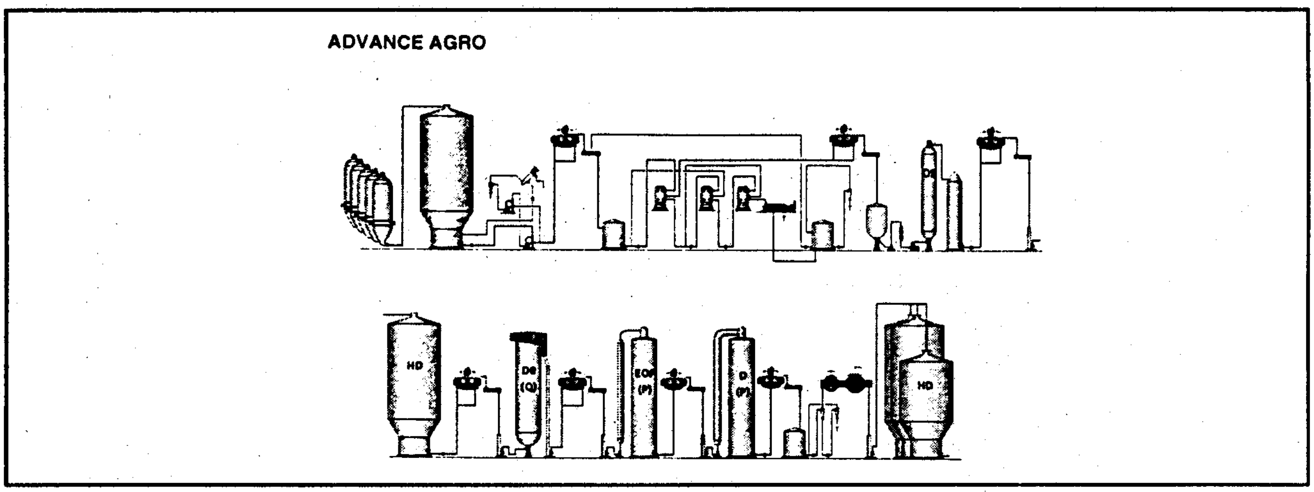

Figure 10. The advance Agro eucalyptus pulp mill in Thailand.

Full brightness of 90+% ISO is reached using only three bleaching stages, D(EOP)D, with less than 35 kg act. Cl/ton and 3 kg H_2O_2/ton. The alkali consumption is remarkably low, about is due to the efficient washing obtained in the presses. The press very efficiently removes the acids from the D_0 stage and little alkali is therefore needed to neutralize the carry-over to the (EOP)-stage.

Another reason for the successful start-up was the ease to operate the TwinRoll™ presses. From a training point of view it was, of course, a clear advantage to have only one type of washer in the whole fiberline. The mill is environmentally very sound, with a total bleach plant effluent volume of approximately 7 m³/ton and the COD content in the effluent is about 11 kg/ton. The bleach plant effluent is used as irrigation water for the eucalyptus plantations.

At AssiDoman Kraftliner, Sweden, a bleach plant for birch kraft pulp was started up in December 1995, figure 11. Pulp of kappa number 17-19 is bleached in the TCF-sequence OQ (PO) to 75-85% ISO brightness depending on the pulp quality needed. Design capacity is 480 t/d. The bleach plant is press based and even though the unbleached pulp has a relatively high manganese content it is possible to bleach to 85+% ISO brightness with good pulp strength properties. The (PO)-and O-filtrates are recycled and the Q-stage filtrate is taken to the parallel unbleached softwood liner mill. By these measures no bleach plant effluent is discharged from the birch pulp mill.

These two mills are good examples of applications of Sunds Defibrator hardwood fiberlines with efficient water utilization and low environmental impact.

At J K Paper mills, India, a new hardwood kraft line with equipment from Sunds Defibrator was

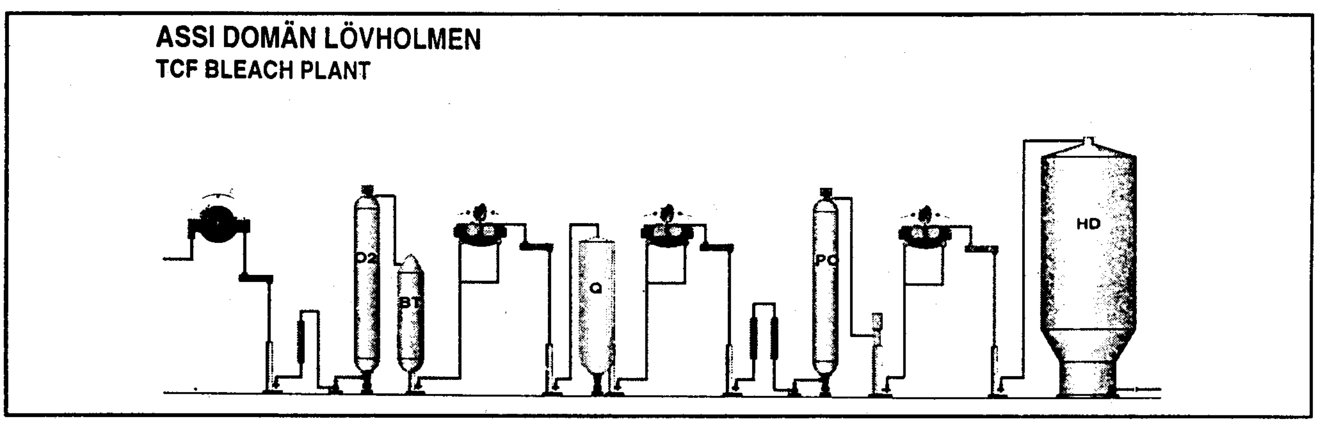

Figure 10. The Swedish AssiDoman Kraftliner Bleach plant for birch pulp.

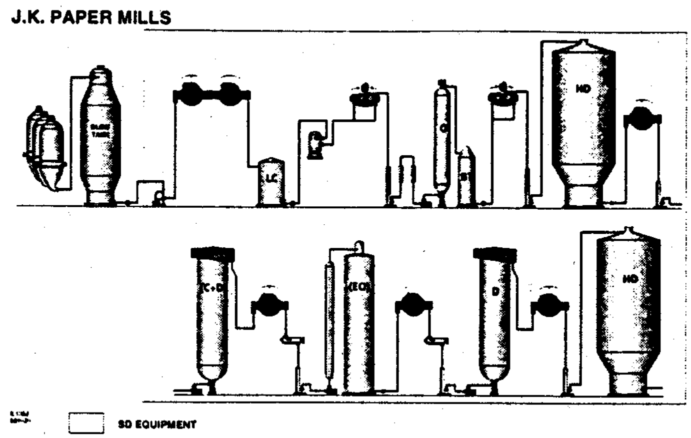

Figure 12. The JK Paper hardwood pulp with the first oxygen delignification stage in India.

installed at the beginning of 1998, figure 12. The delivery included the fiberline after the disgester blow tank, i.e. oxygen delignification, washing, screening and bleaching. This is the first installation of oxygen delignification in India, and, as can be seen in the figure, there are wash presses installed before and after the oxygen stage. This part of the filtrate is taken to the recovery cycle. The bleach plant filtrates are discharged.

COMPARISON BETWEEN A WOOD-BASED AND A NON-WOOD FIBERLINE

Above we have discussed fiber lines for wood-based pulp which is the dominating type of pulp production in the world outside India. However, in India most mills use non-wood fibers as raw material and although the raw material is different the process equipment needed is in principle similar to the corresponding equipment used for processing of wood-based pulp. This is shown in the simplified flow-sheet for TCF-pulp production of 80-85% ISO brightness, figure 13. Thus, the raw material is cooked, washed and screened before oxygen delignification and final

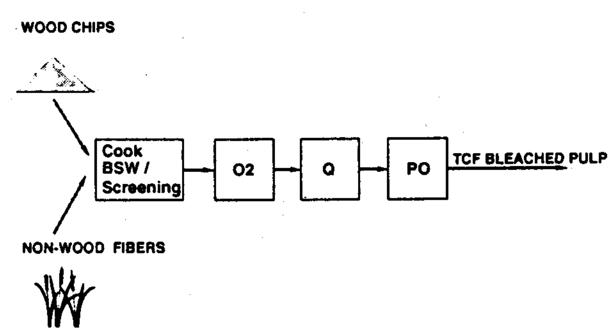

Figure 13. The principles for production of wood based and non-wood based pulp are the same.

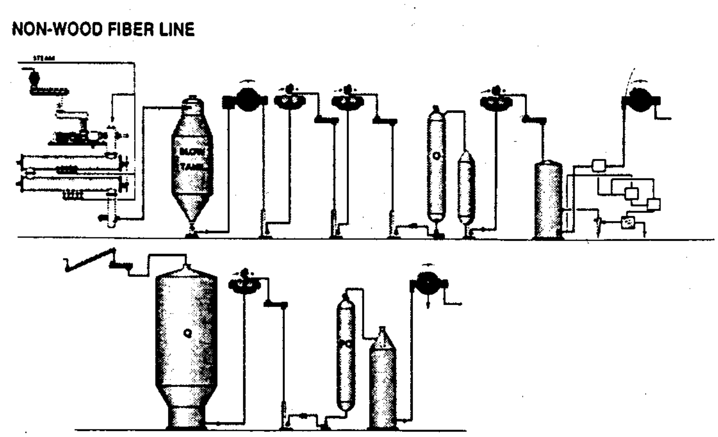

Figure 14. The Sunds Defibrator fiberline for production of non-wood TCF pulp

bleaching in this case in a (PO)-stage after chelation in a Q-stage.

However, although the principle process stages are the same for non-wood pulp production as for wood pulp production the process equipment is slightly different. The digester is quite different and washing is preferentially done with a mixture of presses and filters, as described below in the Sunds Defibrator fiberline for modern non-wood pulp production, figure 14. This line does not exit yet in a mill installation but all parts of it are proven technology and used on mill scale. This concept is particularly interesting for greenfield mills.

In this fiberline light and heavy impurities, such as sand, pith, etc., must first be removed in the best possible way before the raw material is processed in the digester. The pretreated and cleaned straw or depithed bagasse is thus fed to a screw conveyor, where it is compacted to a steam-tight plug. Preheating, which is recommended for wet materials, can be performed at this stage. The straw/bagasse then enters the digester and the plug expands while direct steam and cooking liquor is added. Good mixing is ensured with special designed conveyor flights. The pulp is transported to a discharger and via a blow valve taken to the blow tank. The pulp is diluted in the discharger with chilled (40°C) black liquor, which decreases the pulp temperature below 100°C before blowing. Scrap material is removed from the bottom of the discharger. The total cooking time in the digester is very short due to the favourable impregnation and cooking conditions and on average only 10-20 minutes are needed.

This continuous tube digester system has several advantages over the conventional rotary digesters:

- a better controlled process gives a higher pulp yield
- a better utilization of the added steam, which means that the saving is about 50-60%
- a more uniform pulp quality and improved runnability
- higher pulp strength
- flexible production through controlled retention time
- no separate blow condenser is required
- saving in building costs and man-power

The brown stock washing takes place on one drum filter and two dewatering presses. Together with the post-oxygen washing this part of the washing is performed counter currently. With the presses the power consumption is lower as less water is circulating in the system compared with filters. The advantages of using presses are, as for wood pulp, lower water consumption, an efficient barrier is created between the stages due to the high pulp consistency, smaller variations is wash efficiency as the dilution factor can be well controlled which also gives a very good consistency control. All together this gives saving in power and steam consumption as well as in investment in auxiliary equipment and building.

After washing the pulp is further delignified by oxygen. An efficient oxygen delignification system requires relatively low carry-over from the brown stock wash but also a good consistency control and efficient mixing of oxygen into the pulp. The delignification takes place in a pressurized vessel under alkaline conditions. The pressure at the top of the reactor is 3-5 bar and the temperature 90-100°C. Oxygen delignification is usually giving a kappa reduction of 40-45%, and corresponding reductions both in bleach chemical consumption and in bleach effluent discharge.

After oxygen delignification the pulp is taken to a press, to screening in Delta screens with slotted Nimega baskets and to a drum filter. The Delta screens increase the screening efficiency and reduce the power consumption.

For a greenfield mill it is most attractive to invest in a TCF-bleaching sequence as the chlorine dioxide generation plant can be avoided. A viable sequence for brightnesses of 80-85% ISO, and in special cases even up to ISO, is OQ (PO). The Q-stage is a chelation stage that removes most of the harmful metal ions before the (PO)-stage which is an oxygen reinforced pressurized alkaline peroxide stage. The pressure at the top of the (PO)-reactor is 3-5 bar, and the temperature 90-100°C.

The washer after the Q-stage has to be very efficient to be able to remove as much as possible of the harmful metal ions, like manganese etc., which negatively affects the following peroxide stage and a wash press is therefore used in this position.

The washer after the (PO)-stage could also be a press if more of the residual peroxide is to be recovered and if the COD-content of the pulp after the (PO)-stage has to be very low. However, a drum filter is a cheaper alternative in this position and in many cases such a washer is sufficient.

ENERGY COMPARISONS FOR MODERN VERSUS OLD CONVENTIONAL EQUIPMENT

Energy considerations are important for pulp mills in all countries as steam and power have increasing market values. Therefore, the trend is that new process equipment is designed for more efficient energy utilization. Investment in new process technology is thus usually also an investment in reduced energy consumption calculated per ton of product. Exactly how large energy reduction that be expected and how much of the reduction that is attributed to power versus steam savings, depend on the actual conditions and the requirerments at the mill. Sunds Defibrator has a large knowledge in this field and is more than willing to share it with its customers.

One good example of steam savings in the production of non-wood pulp is to compare the amount of steam needed in a modern Sunds Defibrator tube digester with the corresponding amount for an old rotary digester. In the first case about 2.0 ton of steam per ton of pulp will be required while more than 4.0 ton of steam per ton of pulp is needed in the rotary digester. This is a reduction of more than 50%. If the white liquor can also be indirectly preheated with steam, where the resulting condensate is replacing fresh water in the boiler, the total steam demand can be further reduced by 0.5-1.0 t/t. This means that the total steam consumption can be cut down by up to 75%.

The same comparison for wood-based pulp production results in about 60% saving in steam when modern Super Batch digesters replace old conventional batch digesters. Typical numbers for Super Batch are 0.8t/ton of pulp versus at least 2.0 t/ton of pulp for conventional batch digesters.

Another example reflects the situations in the screen room, where the development has been very rapid during the last couple of years. Traditional fine screening of wood pulp were of centrisorter type with holes in the first stage and slots in the second stage (double-stage screening) and these screens could permit maximum 1.5% inlet pulp consistency. However, our new Delta-screens with Nimega slotted baskets only require one-stage screening (i.e. a single primary stage) and as the maximum pulp consistency in a Nimega screen is 3.0-3.5% significantly less water has to be recirculated around the screens. The reduction in power consumption is therefore often 40-45%. For a wood pulp based screen room of 1200 ADT/d with primary, secondary and tertiary screening this reduction is about 10 kWh/t (a reduction from 23 to 13 kWh/t) or in relative numbers 43%.

A third example is the power consumption of a modern displacement press versus a vacuum filter in a wood-based pulp bleach plant of 1000 t/d. The press (DPA 1255) consumes about 14 kWh/t, while the vacuum filter demands 18 kWh/T; in both cases direct power as well as indirect power for filtrate pumps are included. This power reduction is about 22% and the wash result is better after the press than after the filter. The conventional rule of thumb is that one press corresponds to about 1.5 filters when washing efficiency is compared.

The energy consumption of the recommended OQ (PO)-bleach plant in figure 14 has finally been compared with the traditional CEH-bleach plant for non-wood pulp production to assess its steam and power demand. This has been done both without and with the addition of the power demand for the production of bleaching chemicals, which in many cases represents a substantial power demand. The energy numbers used in this comparison are given in table 3. The actual numbers for the two bleaching sequences are given in table 4. As is seen in the latter table the modern bleaching sequence requires more steam than the traditional CEH-sequence due to the higher temperature (100°C and 95°C) used in the O and (PO)-stages while the C- and H-stages are carried out at 40°C. However, many mills has a steam surplus and in such cases the additional steam consumption is not a problem.

The power demand, on the other hand, is always necessary to keep down, as power has a higher market value. In the OQ (PO)-sequence the direct power demand is in fact higher than in the CEH-sequence mainly due to the pressurized reactors used in the O and (PO)-stages while the bleach towers in the traditional sequence are atmospheric. However, the correct power comparison is to include the power demand for the bleaching chemicals, which is done in the last column in the table. Thus, the modern OQ (PO)-sequence shows its superiority over the CEH-sequence and the total saving is about 90 kWh/t. Furthermore, the OQ (PO)-sequence is possible to close up, i.e. to recycle its filtrates to the brown stock wash, which will significantly reduce its environmental impact. The CEH-sequence is not possible to close up in the same way as it contains large amounts of chlorides, which can cause considerable corrosion in boilers etc. Thus, the CEH-sequence consumes more power and it generates large amounts of organically bound chlorine and COD, which have to be taken to extensive external effluent treatment before it can be discharged to the recipient. Formation of chlorinated dioxines is naturally also a potential problem when chlorine gas is used in the sequence in this way.

EXAMPLES OF INSTALLATIONS IN NON-WOOD FIBER PLANTS

Below four mill examples are given, where part of our concept in figure 14 has been installed.

Table 3. Power demand in the production of bleaching chemicals.

Chemical	kWh/kg
O_2	0.4
DTPA/EDTA	0.1
H_2O_2	0.7
Cl_2	1.8
NaOH	1.6
NaOCl	3.9

Table 4. Steam and power demand for the two bleaching sequences discussed in the paper. The table also includes the power demand for the production of the bleaching chemicals needed to reach 83% ISO brightness.

Sequence	Steam, kg/t	Power kWh/kg	Power bleaching chemical, kWh/kg	Total power demand kWh/kg
OQ(PO)	450	135	40	175
CEH	200	115	150	265

The Packages Ltd. straw fiber line in Lahore, Pakistan, produces liquid board and printing and writing papers based on chemical and CTMP-pulp from wheat straw (65%) and kahi grass (35%), Figure 15. This mills is uncommon among non-wood pulp producers as it has a chemical recovery system, which naturally reduces the pollution load from the mill significantly. The mill has in 1997 started up a tube digester, brown stock washing and screening delivered by Sunds Defibrator. The design capacity is 100 ADT/d and the kappa number after the digester is about 14. The bleach plant, which is of traditional CEH-type, was originally delivered by Sunds Defibrator in the 1960s but it was upgraded in the mid 1990s with

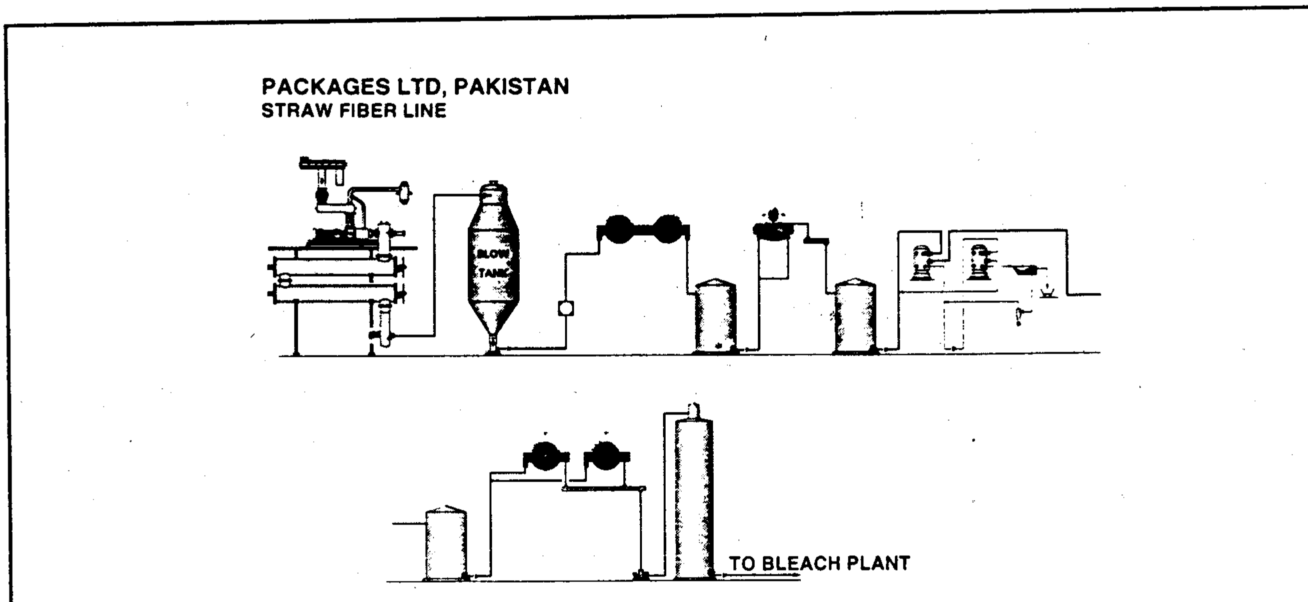

Figure 15. The Packages wheat straw fiber line with digester, brown stock washing and screening from Sunds Defibrator.

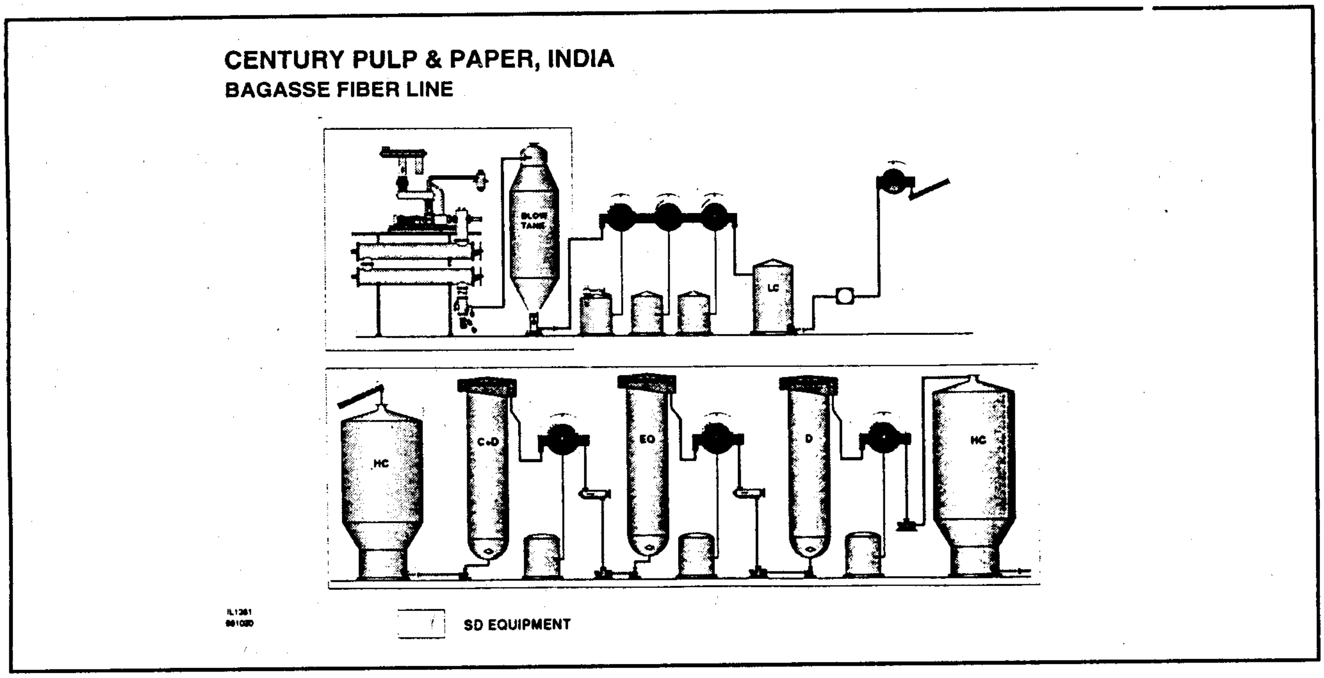

Figure 16. The Century Pulp and Paper mill can produce bagasse pulp of full brightness.

two modern MFA-filters and T-mixers.

After bleaching the brightness of the pulp is 82-83% ISO.

The Century Pulp and Paper company in Lalkua, Uttar Pradesh, India owed by Century Textiles and Industries Ltd, has a bagasse kraft (20% sulfidity) pulp mill comprising a cooking plant from Sunds Defibrator followed by brown stock washing on three filters, screening and a decker. Bleaching of the pulp is done in a (C+D) (EO) D-bleach plant delivered by Sunds defibrator, which raises the pulp brightness to 82-84% ISO with a brightness ceiling of about 88% ISO. The fiber line was started up in 1995 and it has a capacity of 225 BDMT/d, figure 16.

In Dunaujvaros, Hungary, Sunds Defibrator supplied in 1987 the fiberline comprising all equipment

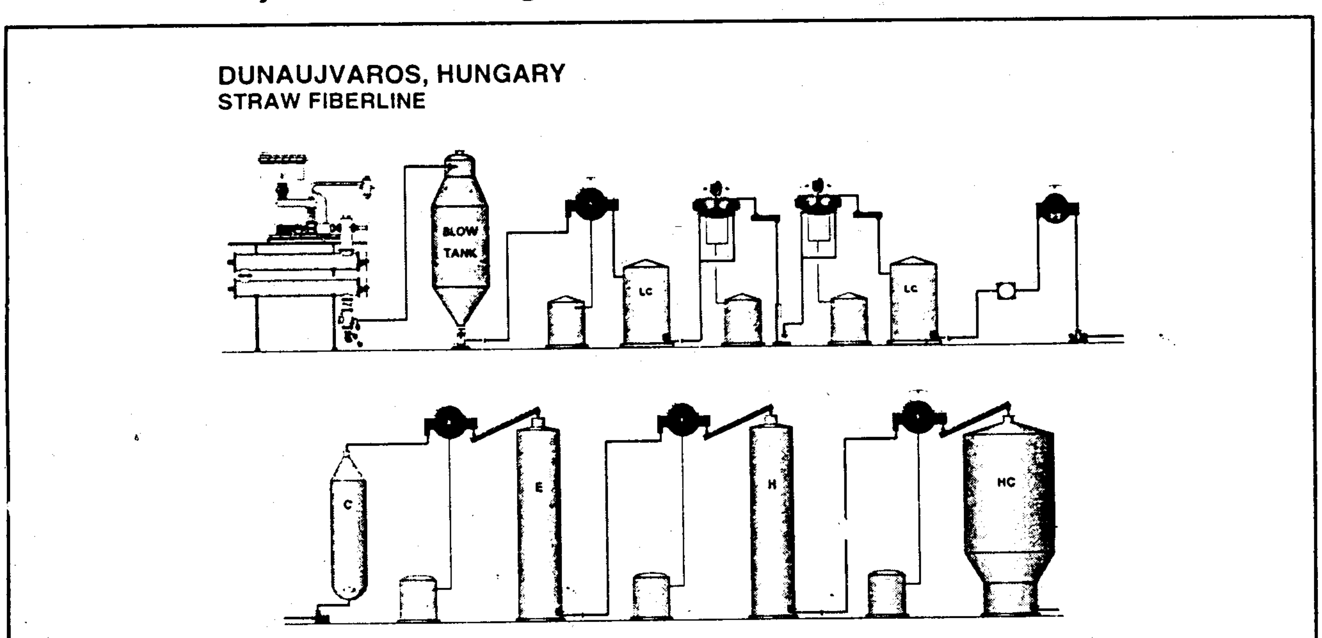

Figure 17. The Dunaujvaros wheat straw fiber line.

from continuous tube cooking to bleaching, figure 17. The delivery was a special honour and challenge to Sunds Defibrator as the quality requirements at this mill are very high. These quality requirements are especially seen in the outstanding work that the mill has put into each process stage from harvesting, storage and pretreatment of the straw. Via careful cooking, washing and bleaching this results in a high-quality bleached product. The wheat straw is kraft cooked to kappa number 14-16 and the pulp is then washed counter-currently on a filter and two press stages, then screened and further bleached to about 82% ISO brightness with the sequence CEH. Design production is 100 ADT/d.

CONCLUSIONS

Modern pulping and bleaching process equipment is more efficient and less polluting and energy-consuming than the traditional process equipment which is still used in many pulp mills in all countries today. Thus, investments in new process equipment has a number of benefits connected to it which also includes savings in steam and power demand at the same time as the production capacity is higher. These benefits are very obvious for non-wood pulp production which is shown in detail in the paper. A special Sunds Defibrator fiber line concept for bleached non-wood pulp is presented where the recommended bleaching sequence is of TCF-type.

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