Energy Recovery in TMP And CTMP Systems

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INTRODUCTION

A major portion of the energy input for TMP and CTMP production is converted to steam.

In the begining of the TMP era in the early 1970s, the generated steam was separted from the pulp in atmospheric cyclones. Figure 1 shows a typical two-stage TMP installation at that time. It comprised a primary pressurized stage and a secondary atmospheric stage.

The steam was released and vented over the roof or to some extent used for heating of water or for local heating. The steam was regarded as waste heat. The energy cost in TMP pulping was high corresponded to the electrical energy cost.

The situation today is quite different. All the steam generated in TMP and CTMP plants is now used in the most efficient way possible.

Steam is separated from the pulp at pressures in the range of 2 to 5 bar, facilitating its use in pulp and paper machine dryers. Steam separation techniques and the full use of the generated steam have become an important part of process know-how and an integral part of the TMP and CTMP systems in use today.

The energy cost in TMP and CTMP pulping, corresponding to the cost for electrical energy, is still high but can be credited for the value of the steam. Due to the drastic increase in oil prices, combined with a slower rate of increase in the cost for electrical energy, the energy situation for an integrated papermill has completely changed. The current energy cost for TMP and CTMP production has almost been halved, compared with the cost at the beginning of the thermo-mechanical pulping era.

Development of energy recovery systems has played a major role in TMP and CTMP pulping during the past decade, a role in which Sunds Defibrator has played an active part. Sunds Defibrator's contribution is described in this paper.

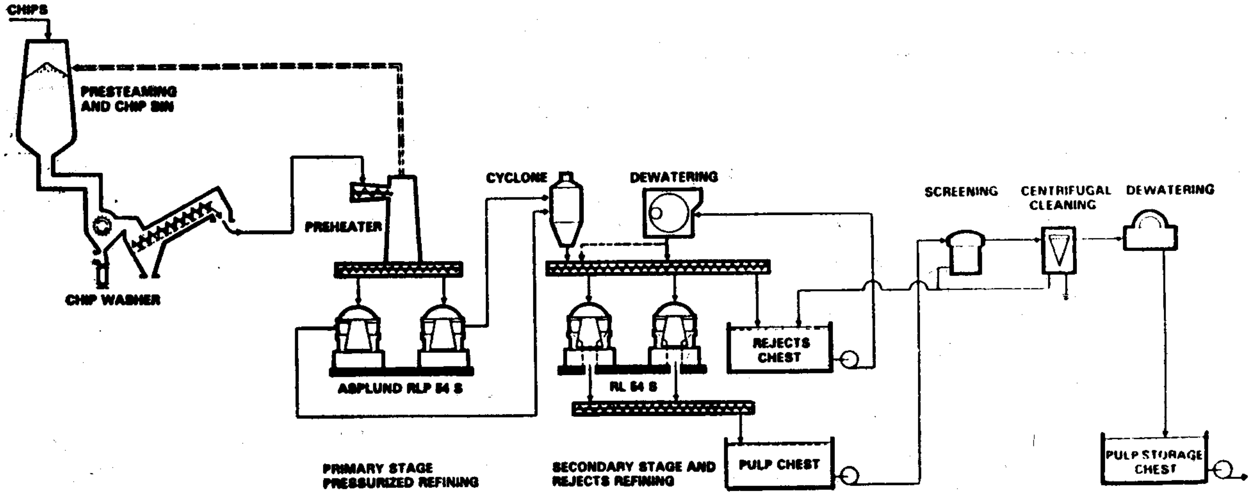


Figure 1. Typical flow diagram of a TMP plant for printing papers.

**Sunds Defibrator AB, Stockholm, Sweden

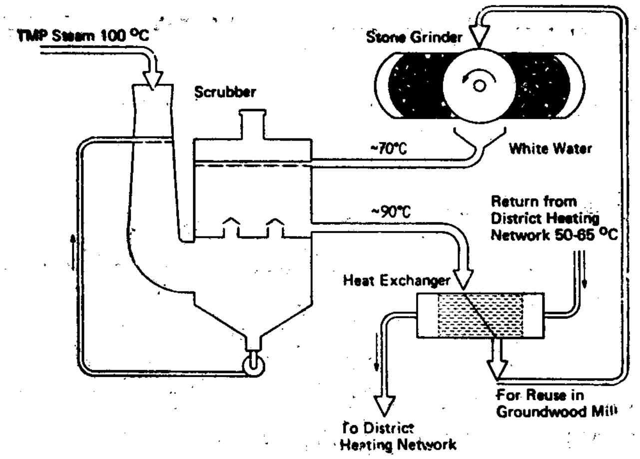
REVIEW OF DEVELOPMENTS

In the first TMP installations, steam was separated from the pulp in atmospheric cyclones. In some instances, the steam was used to produce hot water at about 90°C. The hot water was mainly used as shower water and for local heating However, only a small portion of the released heat could be used in the winter and hardly none during the summer. The payback period for a heat recover plant for hot water production was not impressive.

Using the hot water for municipal district heating was very much discussed at that time. A few installation were placed into operation, such as the Ortviken papermill in Sweden, an integrated plant for production of newsprint. The production capacity of the plant, which is located close to the centre of the town of Sundsvall, is 400,000 tons per year,

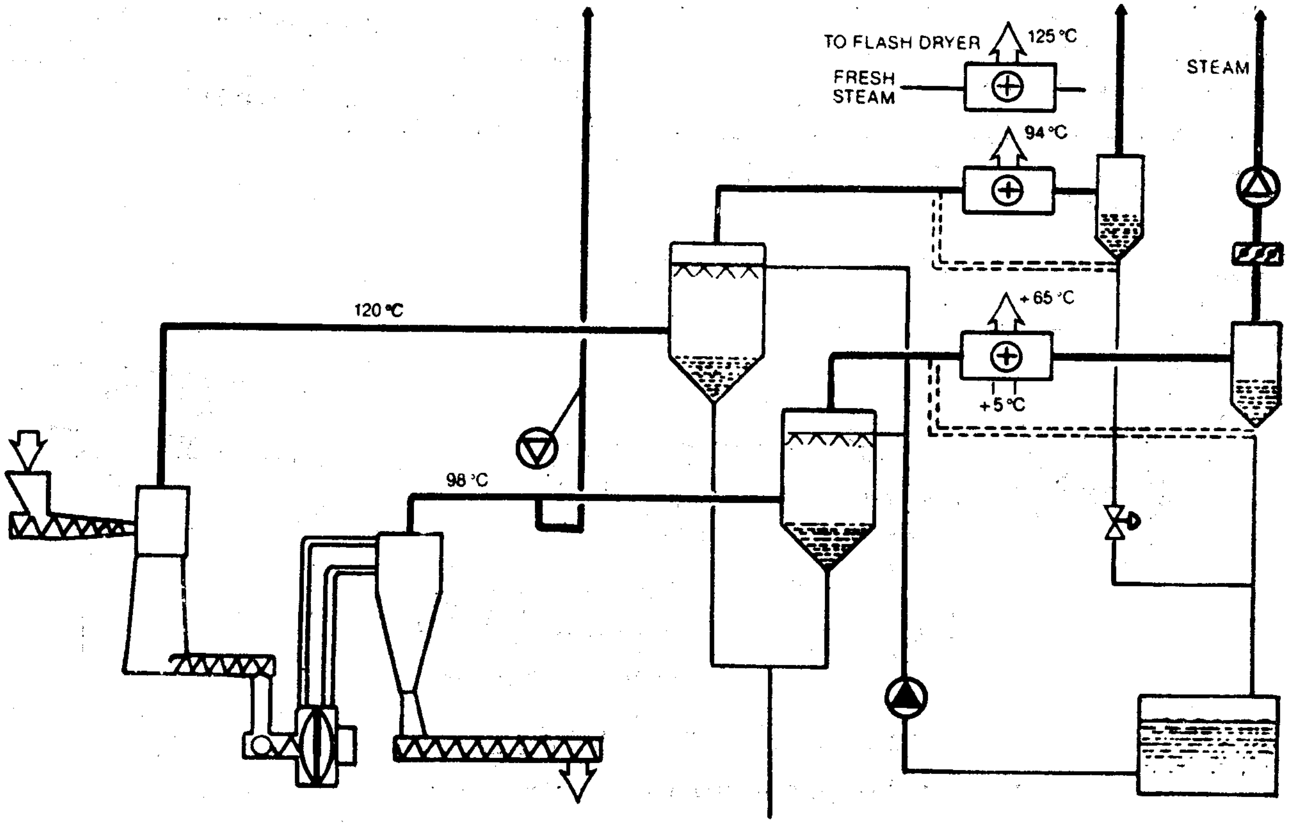
Discussions between Ortviken and the local authorities in Sundsvall led to an agreement covering the delivery of surplus heat from Ortviken to the municipal district heating network. Under the agreement, Ortviken will supply at least 75,000 MWh per year over a 15-year period. This means a savings for Sundsvall of 8,000 m^3 per year of fuel oil in the form of hot water at 85°C[1]. The steam recovery system at the Ortviken mechanical pulp plant is shown in Figure 2.

Figure 2. Flow diagram for district heat production at Ortviken Papermill.



The first step in the development toward a more effective use of released heat was the recovery of TMP steam for heating the air used in flash dryers for pulp drying and for preheating of boiler combustion air. An example of such a system, installed in the Gota market TMP mill in Sweden, which is currently shutdown due to wood shortage, is shown in Figure 3.

Figure 3. Heat recovery from Gota TMP mill.



As shown in the flow diagram, steam from the cyclone at a temperature of about 98°C was used to heat the outside air from +5°C to 65°C. Steam from the top of the preheater at approximately 120°C was used to further raise the air temperature to 94°C. Fresh steam was then used to reach 125°C. The two steam fractions generated in the TMP system were cleaned in specially designed steam scrubbers. The recovery plant, supplied by Svenska Flakt, was designed for a capacity of 6.7 MW, corresponding to a saving of 500 kWh per ton of pulp[2].

To lower the drying temperature and increase the efficiency of using generated steam for drying. Sunds Defibrator developed a disc fluffer for careful desintegration of the pulp and to simultaneously improve heat transfer efficiency. The lower drying temperature also had a positive effect on pulp properties in general. The prototype of this fluffer was tested at the Gota mill.

Many studies were made concerning the feasibility of generating electrical energy with low-pressure, low-temperature TMP steam. Some systems based on the use of liquids with low boiling points such as ammonia were projected. None were ever built, since the economical benefits of these systems were inadequate to justify the investment. Only about 8 percent of the required electrical energy for a TMP mill could be saved.

By 1977, some industry sources were painting a dark future for continued growth of the TMP process, implying that rising energy costs would eventually bring TMP era to a sudden end. They were wrong. In the same year, Sunds Defibrator introduced a pressurized cyclone which marked the turning point in efforts to obtain an energy recovery system which would ensure the survival of the TMP technique. The patented cyclone was designed for vapor-tight discharging[4]. The prototype cyclone, equipped with a high-density pump for discharging, was installed at the Rockhammar mill in their "Thermofiner system".

This system was described in a paper delivered at the Helsinki Mechanical Pulping Conference in 1977[5]. The Thermofiner system comprised atmospheric steaming of the chips followed by pressurized refining—a TMP system without the conventional preheater. With the pressurized cyclone, it was possible to recover air-free steam at over-pressure corresponding to the pressure in the refiner housing.

The next step in the development of efficient energy recovery systems was to introduce the use of reboilers, for "cleaning" of the fiber-contaminated TMP steam, and thermocompressors for increasing the steam pressure up to the level used in paper drying. The first heat recovery system using a pressurized cyclone, a reboiler and a compressor was started up in April 1981 at Holmens Bruk's Hallstavik mill. This system, shown in Figure 5, was described in a paper presented at the Oslo Mechanical Pulping Conference in 1981[6].

Figure 4. Single-stage thermofiner process.

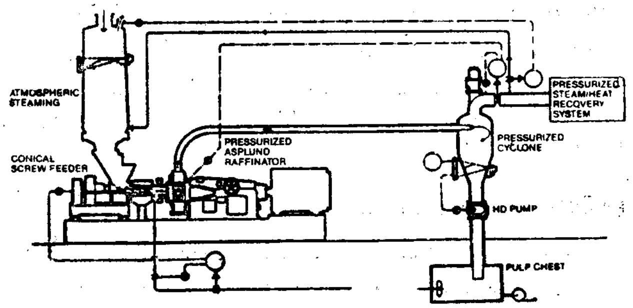
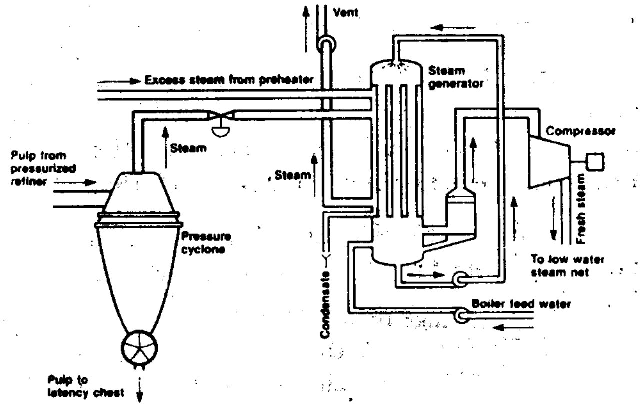


Figure 5. The Hallsta TMP mill, steam recovery system.



Operating data for this mill is presented in Table 1.

Table—1. Heat recovery at the Hallsta papermill

Pulp production (single-stage)	11 ADMT/h
Specific energy	1625 kWh/ADMT
Clean steam generated	15 t/h = 1.36 t clean steam/ton of pulp
Steam pressure before consumption	1.5 bar
Energy for the thermocompression*	60 kWh/ton steam
Clean steam after recompression	16.5 t/h
Clean steam pressure after recompression	3.8 bar

* Note that the energy used for the steam recompressor is not wasted, as indicated by the figures for generated steam before and after recompression.

The latest step in the development of efficient steam recovery system was taken during 1982, when Sunds Defibrator developed a new refining technique for TMP and CTMP systems which permitted an increase in refiner housing pressure from about 2 bar to 5 bar. This technique eliminated the need for a certain amount of steam compression in most cases. It increased the value of the steam, while at the same time it marked the begining of a new understanding of refiner behaviour and the refining process.

NEW TECHNOLOGY

New technological development during the past two years, such as the new refiner systems, as well as improvements in pressurized cyclones, combined with experience in reboiler techniques, have opened what could be referred to as the TMP and CTMP technology for the Eighties.

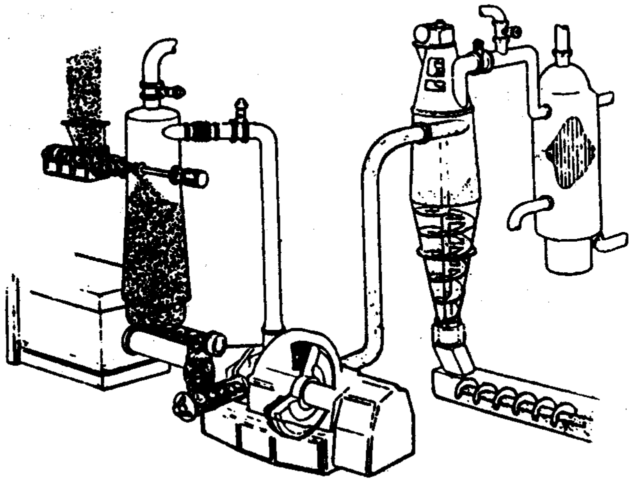
Refiner system developments

During the past two to three years, Sunds Defibrotor's TMP systems underwent a development toward single-stage pulping and pressurized two-stage systems. These developments further increased the potential for complete recovery of steam at high pressure.

Sunds Defibrator has thoroughly investigated the consequences of running the TMP and CTMP refiners at high pressure. Trials have been conducted in systems with single-disc and double-disc refiners.

The single-stage refining unit at the Hallsta Papermill, shown in Figure 6, can be described as a reference installation for these developments.

Figure 6. Single stage TMP unit at Hallasta, equipped with pressure-tight refiner feed screw and pressurecyclone.



Detailed data from some of these trials with a single-disc refiner were outlined in a recent paper presented at the Mechanical Pulping Conference in Washington[7]. The main questions concerning operation of the refiners at high steam pressure (or temperature) concerned the effect on

— brightness, and

— pulp strength properties

As clearly indicated in Table 2, there was no detrimental effect on brightness. It was essentially the same for pulps produced at normal and elevated pressure.

TABLE—2

Effect of preheating and refiner housing pressure on optical properties
(Average figures from six days trials)

Preheater pressure, bar	2.2	2.2	1.0
Refiner housing pressure, bar	2 5	5.0	5.0
Light absorption coefficient, m²/kg	10.7	11.4	10.1
Brightness, ISO%	54.5	53.5	55.2

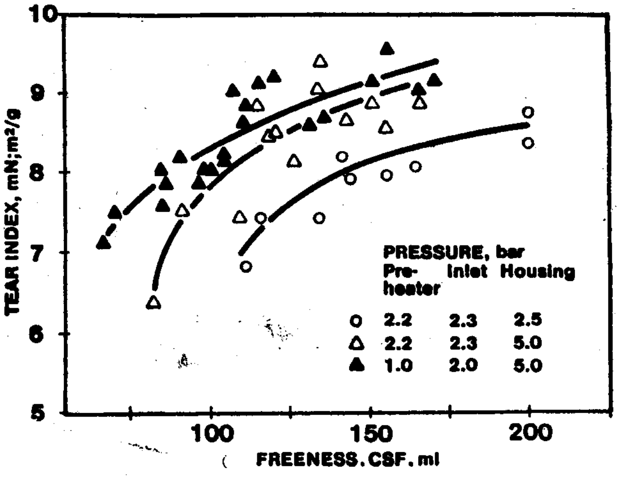
These trials also proved that there were no adverse effects on pulp strength properties. On the contrary, it was discovered that

— long fiber content increased and

— tear index and tensile index improved.

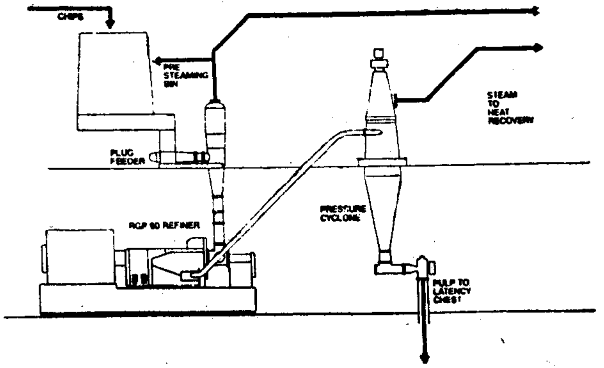
Ter index results are shown in Figure 7.

Figure 7. Tear index versus freeness. Results from trials at the Hallsta single stage refining TMP unit in January 1982.



As a result of these trials, Sunds Defibrator's new TMP and CTMP systems are designed for high-pressure refining after atmospheric presteaming. The latest system shown in Figure 8, which incorporates the new 60" single-disc refiner, RGP 60, is currently in commercial operation at the Braviken mill. This RGP 60 refiner, which is equipped with a 8 MW motor for a production of 100 ADMT/day, incorporates a new design that provides exceptional stability and the very high steam pressure operations that can be of interest in TMP and CTMP pulping in the future. The RGP 60 refiner is designed for a steam pressure of 12 bar.

Figure 8. Principal layout of the Braviken RGP 60 single-stage TMP production line.



Trials conducted with pressurized double-disc refiners have yielded similar positive results. Figure 9 shows the TMP line at the Ortviken mill which comprises an atmospheric preheater and the new 60" double-disc RSP 1500 refiner. This refiner, which has been in operation for more than a year, is equipped with a 12 MV motor for the production of 150 ADMT/day TMP and a steam pressure of 5 bar.

Pressurized cyclone developments

As an integral part of the development work towards continued improvement of the high steam pressure system, Sunds Defibrator redesigned their pressurized cyclone. A sketch of the new cyclone is presented in Figure 10.

In order to get a vapour-tight outlet even at very high pressure, the cyclone has been equipped with compacting screws and a specially-designed blow-out protection device. The size of the cyclone has been reduced due to the higher operating pressures and lower steam volumes. A special feature in the new cyclone is the slow-feed rinsing screw which prohibits cladding at the walls and fiber bridging in the cyclone. This ensures smooth and even operation and a low degree of fiber contamination of the steam leaving the cyclone.

Figure 9. **Principal sketch of the Ortviken RSP 1500 single stage TMP production line.**

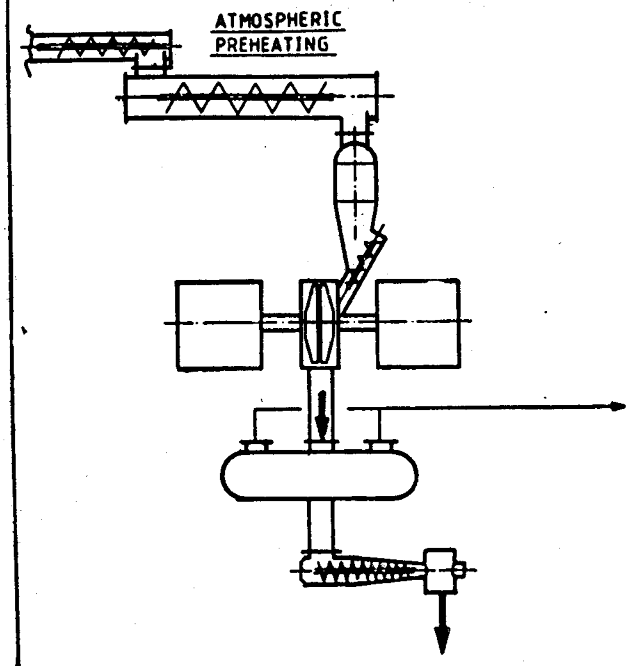
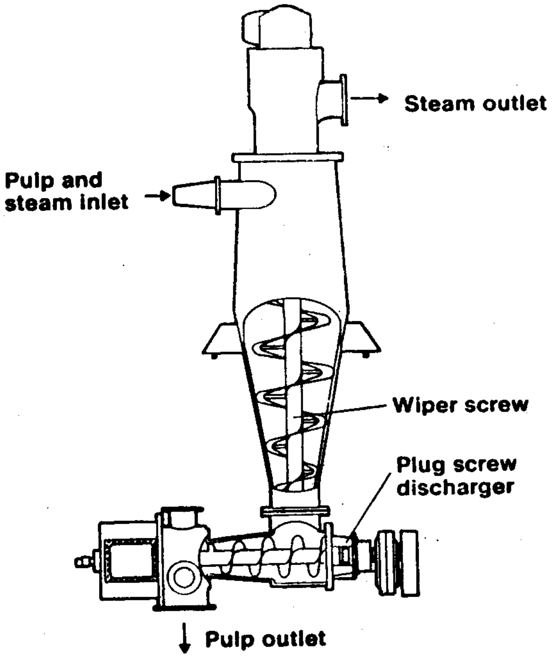


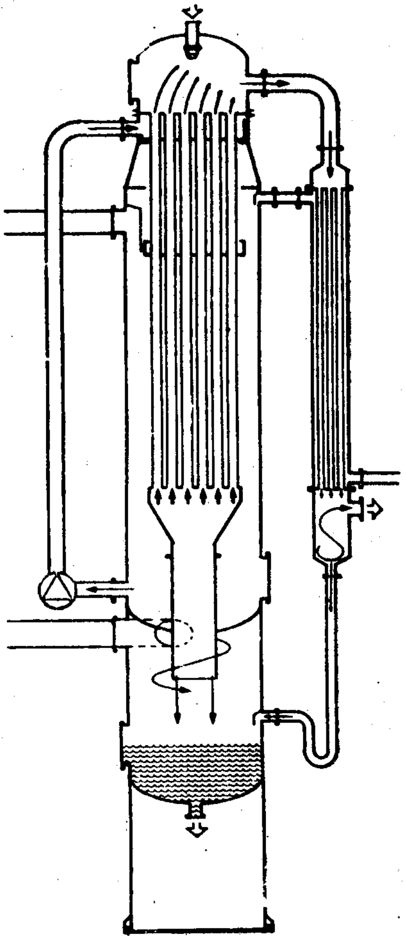
Figure 10. **Sketch showing Sunds Defibrator's pressure cyclone for high pressure steam recovery.**



Reboilers

Currently, several types of reboilers are used for converting TMP steam to clean steam. One of the most common is the falling-film evaporator shown in Figure 11.

Figure 11. Principal drawing of a falling film evaporator.



Three basic types of falling film reboilers are available: verticle tubes, verticle plates and horizontal tubes Clean condensate is recirculated to the perforated plates or distribution trays which distribute it as a thin film to the outside top of the plates or tubes. Horizontal tube type evaporators use spray manifolds to distribute the clean condensate in a thin film. The verticle type of reboiler is promoted as "self-cleaning" since the TMP condensate rinses the inside tube walls as the condensate form and falls by gravity. The falling-film reboiler also operates with a relatively low temperature difference between the fiber-contamfnated TMP steam and the clean steam (8).

In certain cases, the less expensive rising-film evaporator would be a good choice. Though this type of evaporator needs a higher temperature drop than falling film types, it may be the optimal technical/economical solution in combination with steam ejectors, particularly if steam is available from bark boilers, for instance, which must be reduced in any case.

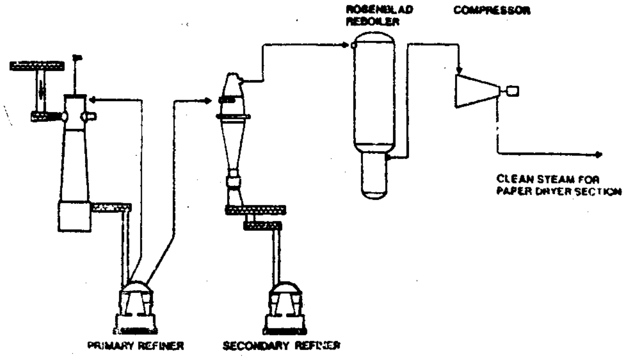
ENERGY RECOVERY SYSTEMS — REFERENCE INSTALLATIONS

To date, Sunds Defibrator has delivered equipment for energy recovery sytems to 15 TMP and CTMP mills, including 65 pressurized cyclones. A few of these installations are described in the following review.

Norske Skogindustrier, Nordenfjelske Mill, Norway

The TMP plant has a capacity of 600 ADMT/D and is equipped with four RLP 58 refiners with 8 MW motors in the primary stage and three RL 58 with 8 MW motors in the secondary stage. The system is shown in Figure 12.

Figure 12. The Nordenfjelske mill, steam recovery system.



The main components of the steam recovery plant are four pressurized refiners, a lamella falling-film type reboiler from Rosenblads Patenter, and thermocompressor from Sultzer.

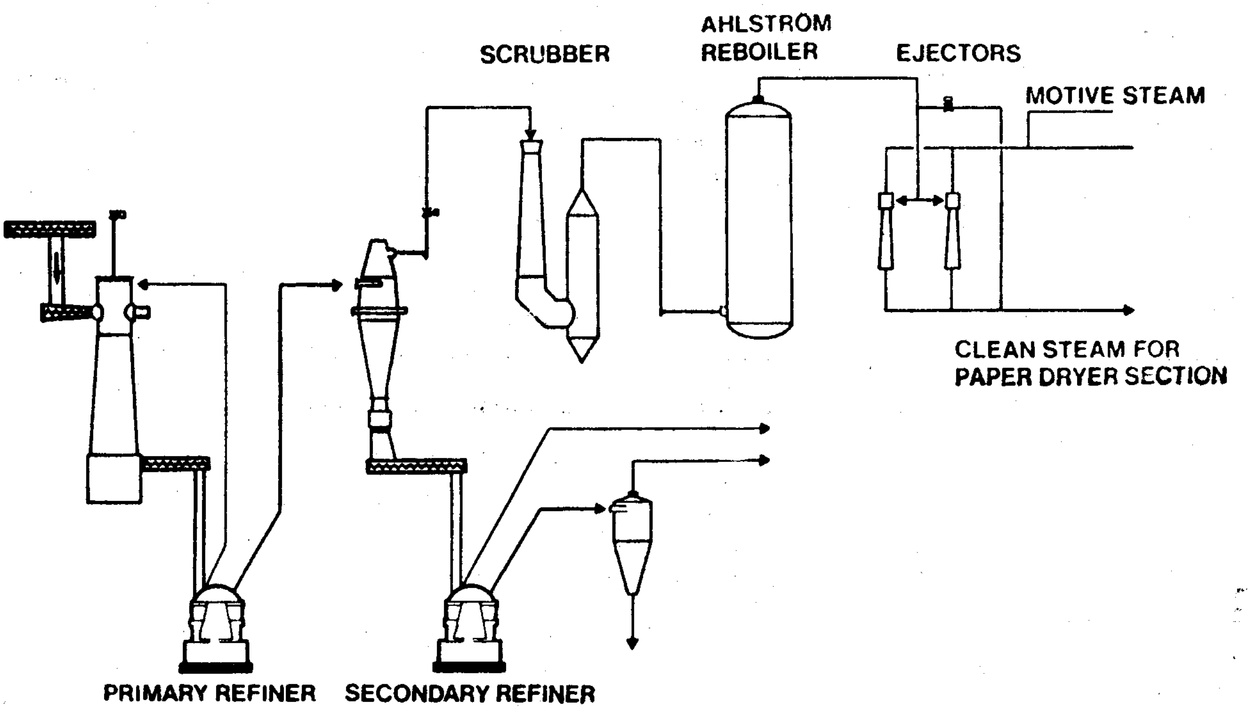
Basic data for the installation is provided in Table 3

Follum Fabrikker, Honefoss, Norway

The TMP plant has a capacity of 250 ADMT/day add is equipped with two single-disc RLP 58 refiners in the primary stage and one RL 58 in the secondary stage. All refiners are equipped with 7.5 MW motors.

The main components in the steam recovery plant are two pressurized cyclones, a lemella falling-film reboiler from Ahlstaom, Finland, and steam ejectors. The recovery system is shown in Figure 13.

Figure 13. The Follum mill, steam recovery system.



Table—3. Basic data, Nordenfjelske

Type of plant	Two-stage TMP for newsprint
Pulp production	600 ADMT/D
Installed motors	1 stage 4 × 8 primary 2 stage 3 × 8 secondary
Generated Steam :	
TMP steam flow	30 t/h
TMP steam pressure	3 5 bar
TMP steam temperature	138°C
Clean steam after reboiler :	
Generated steam flow	30 t/h
Generated steam pressure	2.8 bar
Generated steam temperature	130°C
Clean steam after compression :	
Flow	33 t/h
Pressure	4 bar
Temperature	145°C

Basic data for the installation is presented in Table 4

Table—4. Basic data, Follum Mill

Type of plant	Two-stage TMP for newsprint
Pulp production	250 ADMT/day
Installed motors	1 stage 2 × 7.5 MW 2 stage 1 × 7.5 MW
Generated Steam :	
TMP steam flow	12 t/h
TMP steam pressure	3 9 bar
TMP steam temperature	142°C
Generated Steam after reboiler :	
Generated steam flow	12 t/h
Generated steam pressure	2.8 bar
Generated steam temperature	130°C
Clean Steam after ejection :	
Flow	22 t/h
Pressure	3.7 bar
Temperature	142°C

The energy recovery plant in Follum is situated fairly distant from the papermill. Therefore, a higher pressure is needed. Since high-pressure steam is available from a bark boiler, it is used in an ejector system to increase the pressure of the recovered steam for the TMP plant. This is probably the best and most economical why to increase the pressure of the generated steam, if steam is available that must be reduced.

Billerud-Uddeholm, Skoghall Mill, Sweden

The TMP plant has a capacity of 530 ADMT/D and is equipped with three single-disc RLP 58 refiners on 7.5 MW for single-stage refining.

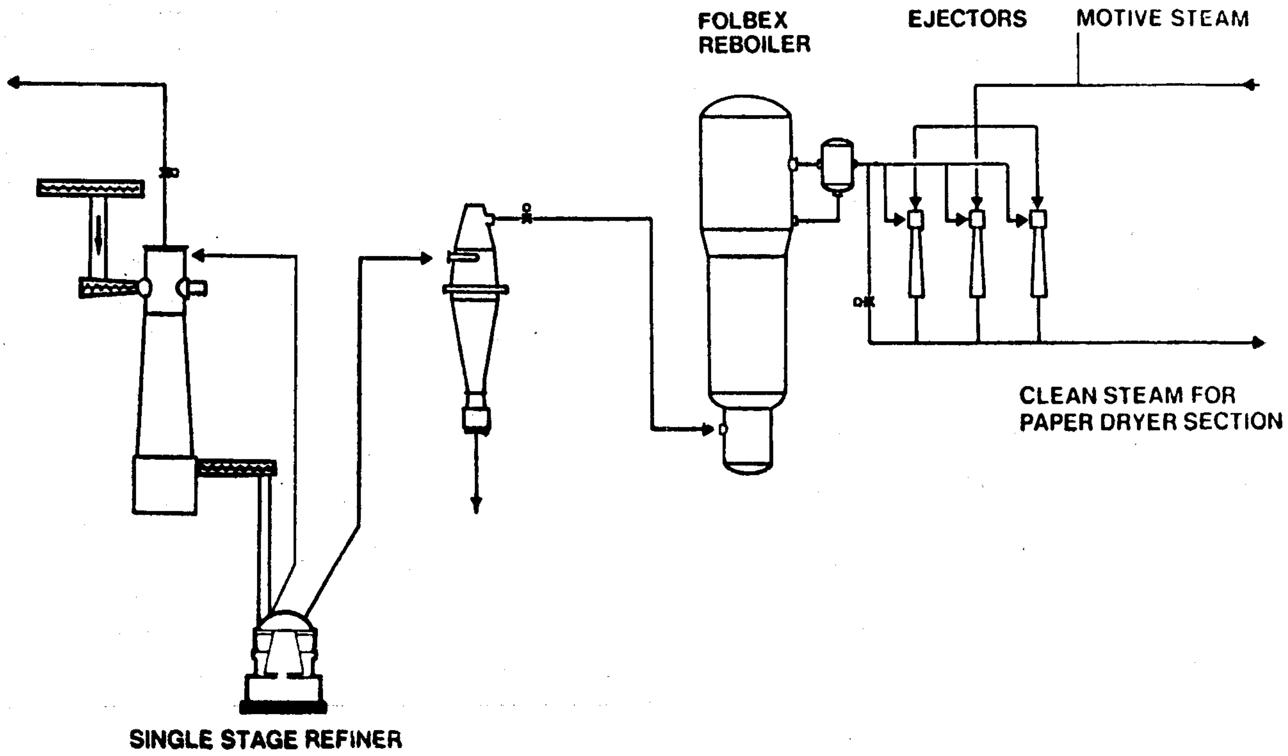
The main components in the steam recovery plant, shown in Figure 14, are three pressurized cyclones, a reboiler of lamella rising-film type from Unozon-Foldex and steam ejectors.

Basic data for the installation is provided in Table 5

Table—5. Basic data, Skoghall Mill

Type of plant	Single-stage TMP foı fluff and paperboard
Pulp production	530 ADMT/D
Installed motors	3×7.5 MW
Generated Steam :	
TMP steam flow	21 t/h
TMP steam pressure	4.2 bar
TMP steam temperature	145°C
Clean Steam after reboiler :	
Generated steam flow	21 t/h
Generated steam pressure	3.6 bar
Generated steam temperature	125°C
Clean steam after ejectors :	
Flow	40 t/h
Pressure	4.5 bar
Temperature	150°C

Figure 14. The Skoghall mill, steam recovery system.



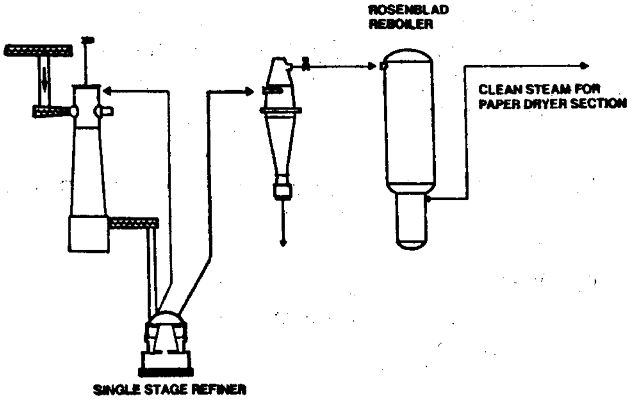
The recovery plant at Skoghall is the first installation using a rising-film evaporator.

Stora Kopparberg's Kvarnsveden Papermill, Sweden

The TMP plant has a capacity of 335 ADMT/D and is equipped with two single-disc RLP CD 70 refiner on 13 MW for single-stage refining.

The main components in the steam recovery plant, depicted in Figure 15, are two pressurized cyclones and a reboiler of lamella falling film type from Rosenblads Patenter,

Figure 15. The Kvarnsveden mill, steam recovery system.



Basic data for the installation are given in Table 6.

Table 6—Basic data, Kvarnsveden Papermill

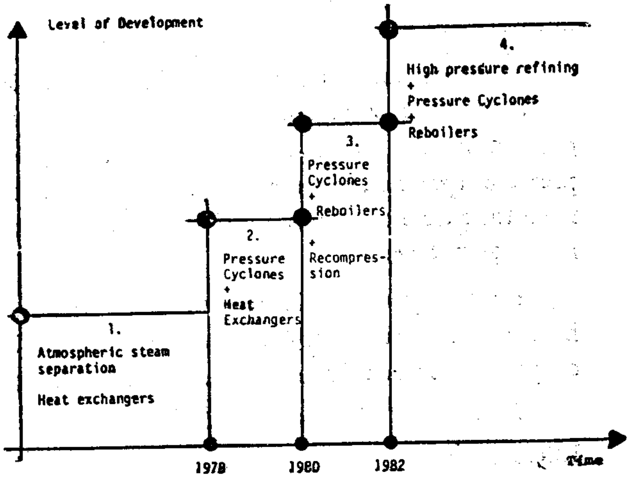
Type of plant	Single-stage TMP for newsprint
Pulp production	335 ADMT/D
Installed motors	2× 13 MW
Generated Steam:	
TMP steam flow	27 t/h
TMP steam pressure	4.2 bar
TMP steam temperature	145°C
Clean Steam:	
Generated steam flow	24 t/h
Generated steam pressure	3.7 bar
Generated steam temperature	125°C

The Kvarnsveden installation is one of the most modern, efficient and straight-forward steam recovery plants in the world today.

CONCLUDING REMARKS

The rapid development of the energy recovery systems that has been discussed in this paper is summarized in Figure 16.

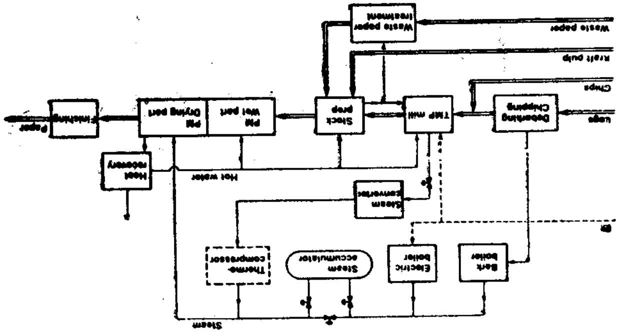
Figure 16. Energy recovery systems, development steps.



This development has had, and will have, the greatest influence on the economy of "wood-containing paper and paperboard production. The following example illustrates this point.

Integrated newsprint mills, for intance, will most likely have a different look in the future. New mills will probably be built with a bark boiler as the only steam source, supplemented with a stand by electrical boiler such as in the mill depicted in Figure 17. This mill design was taken from an article in which these new thoughts are outlined (2).

Figure 17. The basic concept of a newsprint mill without a fuel oil boiler



With a fuel oil price of SEK 1800 m², the saving in production of newsprint from 100% TMP compared with traditional newsprint from 25% GWD and 15% BKP using fuel oil in a boiler for steam generation will be in the range of SEK 30 million per year for a 165,000 ADMT/year mill.

As a result of favourable results achieved to date in the use of CTMP pulps for fluff, tissue and paperboard grades, a rapid expansion in CTMP market pulp mills is foreseen.

A typical single-stage CTMP installation is shown in Figure 18. It comprises a PREX unit for the impregnation of the chips, a pressurized refining stage, a pressure cyclone and a reboiler. The steam is separated from the pulp at a pressure of 5 bar, facilitating its use in the pulp dryer.

For the type of mill shown in Figure 18, the new heat recovery technique will have the greatest influence on production cost simply by eliminating the fuel cost in drying.

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Figure 18. Typical flow diagram of a CTMP plant for tissue and paperboard grades.