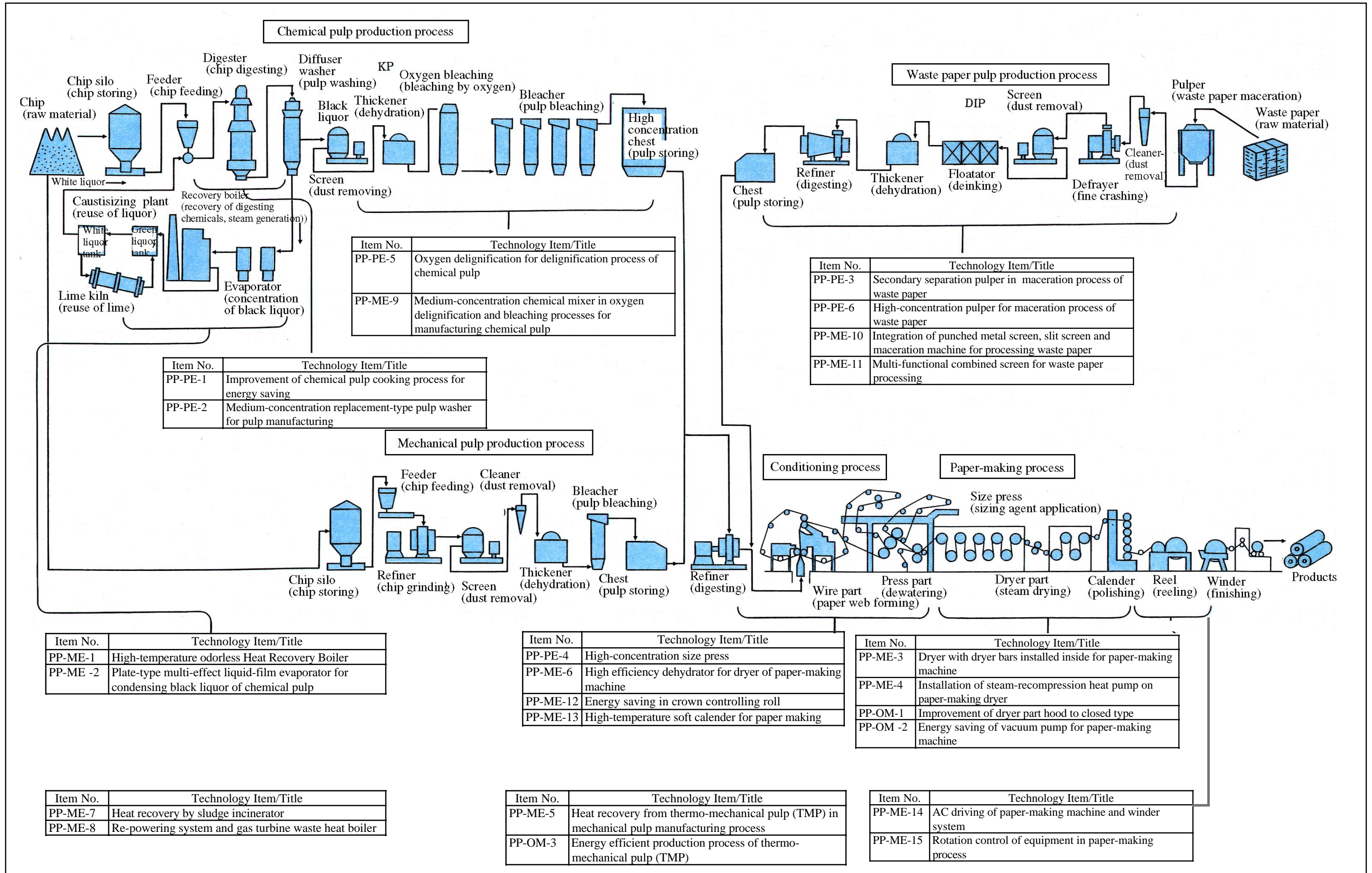


Section 6
Pulp & Paper Industry

Process Flow
Data Sheets

Pulp & Paper : Production Process and Energy Saving Technology

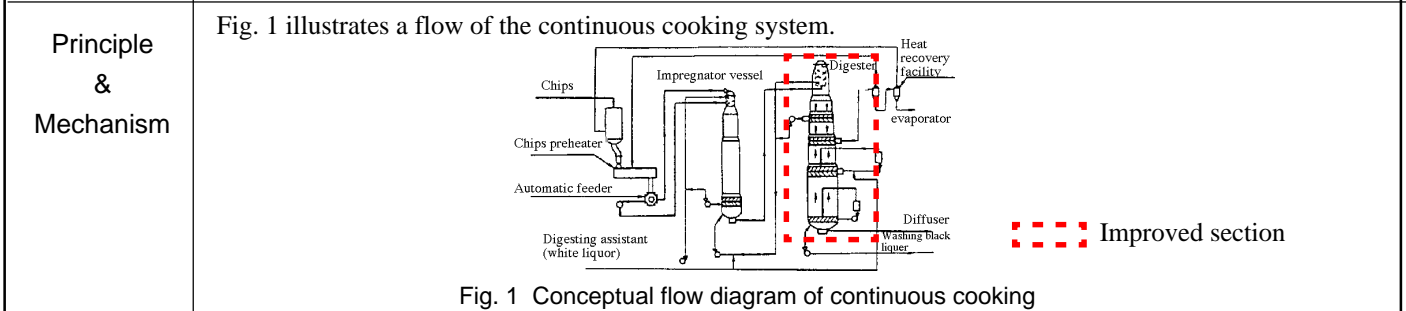


Energy Conservation Directory

PP-PE-1

[Industry Classification] Pulp & Paper	Modification of the cooking process for manufacturing chemical pulp for energy saving	[Energy Source] Fuel
[Technology Classification] Production Equipment		[Practical Use] 1970s-

Outline
 Cooking in pulp manufacturing is a process which processes wood into pulp by removing unnecessary lignin component, normally done by cooking wood chips under pressure in a digester with white liquor, an aqueous solution containing caustic soda and sodium sulfide at a ratio of 7 to 3. Formerly, this operation was done in batch digesters with which it was difficult to recover waste heat when a batch of cooking operation was done. The batch operation was also associated with environmental problems. As a measure to solve these problems, the continuous digester has been developed, with resultant improvement in energy saving.



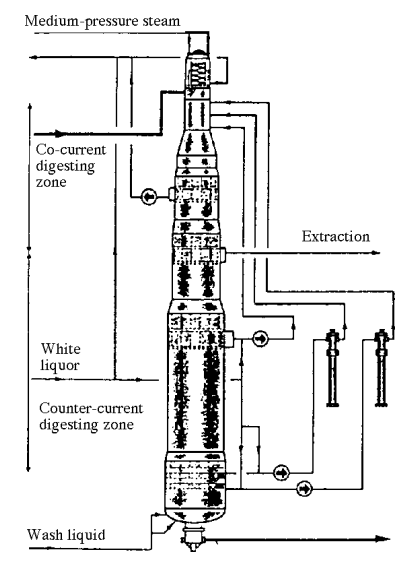
[Description]
[Countercurrent continuous digester]
 Formerly, the entire white liquor for the batch was added at once. The continuous digester injects the white liquor to the bottom and middle of the digester column from which the liquor flows upward inside the column countercurrently to the movement of the wood chips. This system allows mild and uniform cooking.

[Isothermal continuous digester] (Refer to Fig. 2.)
 The temperature of the washing zone at the bottom of the column was raised to make the temperature of the whole digester uniform to further complete uniform cooking.

[Low-solid-matter continuous digester]
 This digester operates at low concentrations of dissolved lignin and low concentrations of total alkalis at the latter stage of the cooking operation while it keeps the sulfidity high at the initial stage of cooking operation.

With such improvements of cooking method, the cooking temperature was lowered by 10°C, the yields of pulp increased and the requirement of white liquor was decreased. However, shifting from the traditional batch digester to the continuous digester prolongs the operation time and therefore productivity is slightly lowered. This is a problem which remains to be solved.

Fig. 2 Isothermal continuous digester



Energy saving effects

Table 1 Energy saving effect and environmental improvement effects before and after improvement

	Before modification (batch digester)	After modification (continuous digester)	Effect
Unit consumption of steam, hardwood	1.12 t/t	0.68 t/t	40% reduction
Unit consumption of steam, softwood	1.45 t/t	0.77 t/t	70% reduction
Reduction of CO ₂ emission			40% to 70% reduction

[Economics]
Equipment cost
 Investment amount (A): 3,700 million yen
 Improvement effect (B): million yen/year
 Investment payback (A/B): years

Remarks

[Example sites]	[References] The Journal of Japan Technical Association of the Pulp and Paper Industry (Vol. , No. 5, 1985; Vol., No. 4, 1990)	[Inquiry] Japan Paper Association / ECCJ (JIEC)
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PP-PE-2

Energy Conservation Directory

[Industry Classification] Paper & Pulp	Pulp manufacturing process, replacement-type pulp washer for digested pulp of medium concentration	[Energy Source] Electricity
[Technology Classification] Production Equipment		[Practical Use] 1970s

Outline
Formerly, the digested pulp was washed by counter-current multi-stage washing by rotating vacuum drum washers. The method was capable of washing only dilute pulp solutions of about one percent. The medium-concentration pulp required a large quantity of dilution liquid.
The present technology enables the pulp to be continuously washed at about ten percent concentration, the same concentration at the outlet of the digester, in a closed vessel, thereby achieving energy saving, environmentally compatible operation of the plant and better plant performance.

Before Improvement
[Problems with the multi-stage rotating vacuum drum washer]
- This washing system requires a large quantity of dilution liquid and hence consumes a large amount of power.
- This washing system is associated with foaming of the dilution liquid, necessity to use foam depressants, and greater heat loss.

[Description of Improvement]
The medium concentration replacement-type washers are available in two different types; namely, pressurized diffuser type as shown in Fig. 2 and closed pressurized drum type as shown in Fig. 3.

Structure explanation, Shape, and/or System diagram

1) Characteristics of pressurized diffuser washers
- The pressurized diffuser was commercialized in 1983. The diffuser is placed immediately downstream of the digester and makes use of the temperature and pressure at the outlet of the digester. In this way, it enhances the washing efficiency.
- The use of diffuser can dispense with the blow tank and feed pump.
- One diffuser-type washer is 1.5 times as capable as one conventional vacuum drum washer.

2) Characteristics of closed pressurized drum-type washer
- Integration of two to four stage washers in the mill could realize a high washing effect.
- This system can save the area of installation and power.

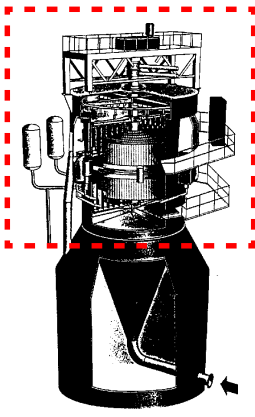


Fig. 1 2-stage screen diffuser

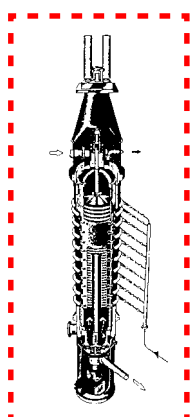


Fig. 2 Pressurized diffuser

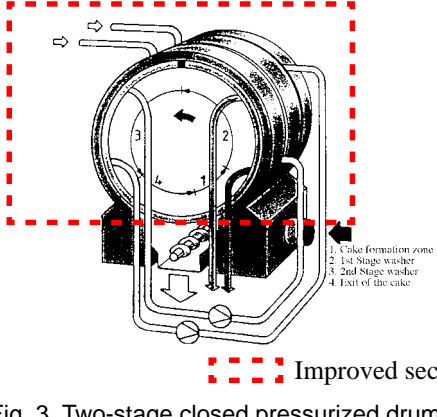


Fig. 3 Two-stage closed pressurized drum-type washer

 Improved section
1. Cake formation zone
2. 1st Stage washer
3. 2nd Stage washer
4. Exit of the cake

Energy saving effects

Table 1 Energy saving effect of the medium concentration replacement-type washer

	Conventional washer	Modified washers		Effects
		pressurized diffuser	closed pressurized drum type	
Installed motor capacity	1,250 kW	400 kW	535 kW	68% reduction 715 kW (57% reduction)
Energy saving -crude oil equivalent*		715 x 0.8 = 572 kWh -> 4,118,000 kWh/y 1,000 kL/y		

Note *: Operating condition, Closed pressurized type, 24h/D, 300D/y

[Economics] Equipment cost
Facility specification: Pulp production of 500 t/D. The plant cost includes equipment and construction, but excludes buildings and foundations.
Cost of a pressurized-diffuser-type washer: 400 million yen
Cost of a normal-pressure-diffuser-type washer: 400 million yen
Cost of a pressurized-drum-type washer (with 4 stages): 700 million yen.

Remarks

[Example sites]	[References] The Journal of Japan Technical Association of the Pulp and Paper Industry (Vol.39 , No.1, 1985, P.105; Vol.48, No.1, 1994, P.105 ; Vol.51, No.11, 1997, P.73)	[Inquiry] Japan Paper Association / ECCJ (JIEC)
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PP-PE-3

Energy Conservation Directory

[Industry Classification] Paper & Pulp	Installation of the secondary separation pulper for maceration of collected waste paper	[Energy Source] Electricity
[Technology Classification] Production Equipment		[Practical Use] 1970s~

Outline
 The pulper is a facility to facilitate maceration of collected wastepaper to form a slurry and to remove large foreign materials. The pulper swells fibers to promote maceration and adds a small amount of caustic soda to help remove inks when the paper treated requires deinking. Formerly, wastepaper was soaked in water at a low rate of only several percent and vigorously agitated by a rapidly revolving impeller to achieve maceration by slashing; in such an operation foreign materials were crushed. The drawbacks were that the crushed foreign materials must be removed in the subsequent processes and the rotation and agitation consumed a large amount of power; in other words, the former process was very low in energy efficiency. The secondary pulper has been developed as a countermeasure against these drawbacks. The secondary pulper conducts preliminary maceration and continuously removes foreign materials without breaking them. Use of the secondary pulper could reduce the degree of maceration and hence could achieve energy saving in the total operation of wastepaper processing.

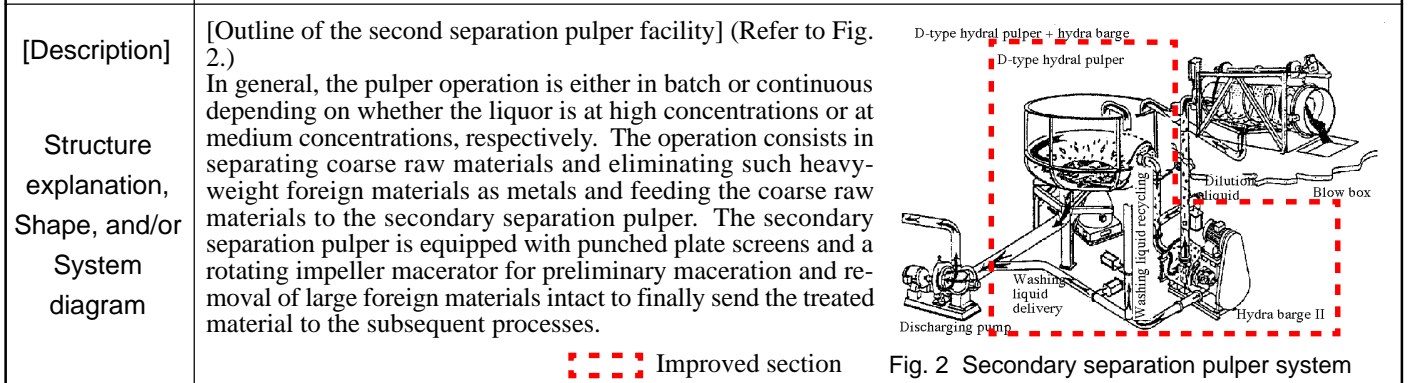
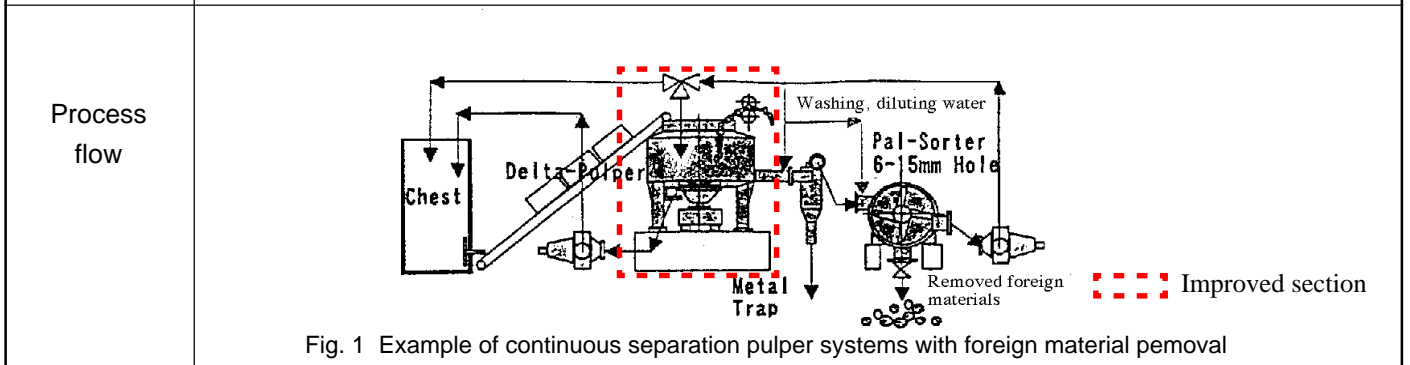


Table 1 Effect of secondary separation pulper (Feed: Collected waste corrugated fiberboard)

	Conventional system	After introduction of secondary separation pulper
Major equipment	67 m ³ pulper (550 kW)	67 m ³ pulper (550 kW), Secondary separation pulper (110 kW)
Production	365 t/D	445 t/D (20% increase)
Pulper cleaning by blowing	Once or twice a day	Not necessary
Concentration of the finished slurry	Varying between 2.0% and 3.5%	Stable at about 3.5%

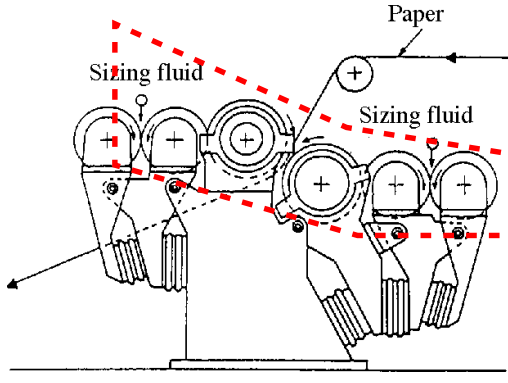
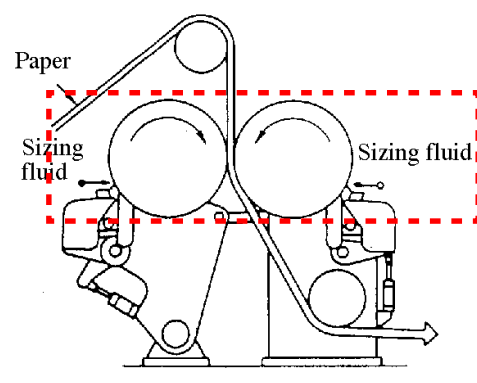
Energy saving effects
 Addition of the secondary separation pulper could increase processing capacity by 20 percent. However, it does not achieve energy saving in the maceration process alone. It could facilitate the subsequent dust removal operation by removing foreign materials without crushing them. For this reason, it has a great energy saving effect on the total processing of waste paper in this way.

[Economics] Equipment cost
 Investment amount (A): 80 to 90 million yen
 Improvement effect (B): 70 million yen/year
 Investment payback (A/B): 1.2 years

Remarks
 The average electric power consumption in the maceration process is 66 kW/ton when processing old newspaper including deinking and 52 kWh/ton when processing used corrugated fiberboard.

[Example sites]	[References] The Journal of Japan Technical Association of the Pulp and Paper Industry (Vol. 46, No. 11, 1992, P. 48; Vol. 51, No. 11, 1997, P. 49)	[Inquiry] Japan Paper Association / ECCJ (JIEC)
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Energy Conservation Directory

PP-PE-4		High-concentration size press	
[Industry Classification] Paper & Pulp			[Energy Source] Fuel (steam)
[Technology Classification] Production Equipment			[Practical Use] 1985-
Outline	The size press coats sizing fluid on the surface of the sheet paper at the dryer part to improve the printing performance. Formerly, it was difficult to coat the sizing fluid of high concentration. This improvement enables to coat high-concentration sizing fluid, reduces the drying load, and makes high-speed coating possible.		
Principle & Mechanism	<ol style="list-style-type: none"> 1) Traditionally, the maximum concentration of sizing fluid was about 8%. With this improvement, the concentration may be raised to 22%, and reduces the drying load. 2) With this equipment, the coating thickness can be adjusted as required. Coating up to 2.0 to 2.5 g/m² is possible. At pigment coating, the concentration can be increased to a level as high as 60%. 		
[Description]	<p>[Structure of size press] (Refer to Figs. 1 and 2)</p> <ol style="list-style-type: none"> 1) The improved size press is equipped with coater heads constituted of metaling rods or blades which control the coating thickness. The conventional size press uses a pair of applicator rolls. 2) The coating weight is controlled by the shape of the grooves of the metaling rods, the angle of the blades, and linear pressure. The coating weight on the front and rear sides can be controlled separately. The coating weight can also be controlled along the width. 		
Structure explanation, Shape, and/or System diagram	<div style="display: flex; justify-content: space-around; align-items: flex-start;"> <div style="text-align: center;">  <p>Fig. 1 Size press of gate- roll type</p> </div> <div style="text-align: center;"> <p>Combination of blades and size fluid coating rolls</p>  <p>Fig. 2 Size press of rod-blade type</p> </div> </div>		
Energy saving effects	The consumption of drying steam after coating is reduced by 50%.		
[Economics] Equipment cost	Investment amount (A): 200 to 250 million yen Improvement effect (B): 60 million yen/year Investment payback (A/B): 3 to 4 years		
Remarks			
[Example sites] Adoption is increasing.	[References] Makers' in-house technical documents	[Inquiry] Japan Paper Association / ECCJ (JIEC)	

PP-PE-5

Energy Conservation Directory

[Industry Classification] Paper & Pulp	Oxygen delignification for delignification process of chemical pulp	[Energy Source] Electricity
[Technology Classification] Production Equipment		[Practical Use] 1990s -

Outline
In a conventional delignification process, chlorine was used as a bleaching agent. Environmental consideration promoted conversion from chlorine to oxygen, which is a cleaner bleaching agent. However, as oxygen is more damaging to fibers than chlorine, only one-half the consumption of chlorine is replaceable by oxygen at most. Recently the PSA oxygen manufacturing process is extensively used. Further the two-stage oxygen treatment method was developed, which can remove more lignin using the same amount of oxygen. These developments greatly contributed to the reduction of electric power consumption.

Principle & Mechanism
[Characteristics of oxygen treatment]
1) Treated waste water can be recycled. Sludge can be burned and heat is recovered.
2) The two-stage treatment method consumes oxygen of 15 and 21 kg/t-pulp for treating hardwood and softwood, respectively.
3) Decrease in residual lignin as expressed in terms of a substituting index of decrease in effective chlorine consumption is 27 kg/t-pulp (50% reduction) and 48 kg/t-pulp (60% reduction) for hardwood and softwood, respectively.

[Description]
[Two-stage oxygen delignification process] (Refer to Fig. 1)
Oxygen is less selective than chlorine and therefore tends to damage fibers. For this reason oxygen bleaching is done at the initial stage of bleaching where lignin still remains on the surface of fibers.

Structure explanation, Shape, and/or System diagram

Fig. 1 Flow of the two-stage oxygen delignification process

	Before	After	Effect
	Cl ₂ 1500kWh/t-Cl ₂	Cl ₂ + O ₂ 270kWh/t-O ₂	
NB	120kg - Cl ₂ /t-Pulp	48kg-Cl ₂ /t-Pulp+21kg-O ₂ /t-Pulp	
LB	81kg-Cl ₂ /t-Pulp	27kg-Cl ₂ /t-Pulp+15kg-O ₂ /t-Pulp	
Electricity	180kWh/t-Pulp 81kWh/t-Pulp	72+7.8=79.8kWh/t-Pulp 40.5+5.6=46.1kWh/t-Pulp	100kWh/t-Pulp (Reduction) 35kWh/t-Pulp (Reduction)

Fig. 2 Trend of specific power consumption by PSA oxygen manufacturing

Energy saving effects

Table 1 Comparison of energy-saving effects by conventional chlorine treatment and two-stage oxygen delignification

	Conventional chlorine treatment	Two-stage oxygen (PSA) delignification	Effects
Specific power consumption	1,500 kWh/t-Cl ₂	370 kWh/t-O ₂	Reduction of 1,130 kWh/t (75%)
Associated effect			Recovery of black liquor: 65 g/t (about 4%) for hardwood

[Economics] Equipment cost
Specifications of the equipment
Pulp production: 500 tons/d, two-stage oxygen treatment including post-treatment washing
Cost of the equipment: about 1,600 million yen, Can be employed for dioxin prevention.

Remarks
Although the oxygen delignification process was in use since around 1975, the two-stage oxygen treatment was started to be extensively used in more recent years of the 1990s.

[Example sites] Adopted at almost all the plants in Japan.	[References] The Journal of Japan Technical Association of the Pulp and Paper Industry (Vol. 38, No. 12, 1984, P. 1; Vol. 42, No. 1, 1988, P. 52)	[Inquiry] Japan Paper Association / ECCJ (JIEC)
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PP-PE-6

Energy Conservation Directory

[Industry Classification] Paper & Pulp	High-concentration pulper for maceration process of waste paper	[Energy Source] Fuel
[Technology Classification] Production Equipment		[Practical Use] 1972 -

Outline
A new pulper was developed in the 1980s and has been extensively used since then. This new pulper macerates waste newsprint papers, one of the easiest to macerate, by slowly whirling and agitating it at a high concentration of about 15%. This pulper does not break foreign materials, and consumes only the same level of power as a low-concentration pulper.

Principle & Mechanism

[Mechanism of drum-type high-concentration pulper and example of specification] (Refer to Fig. 1 and Table 1)

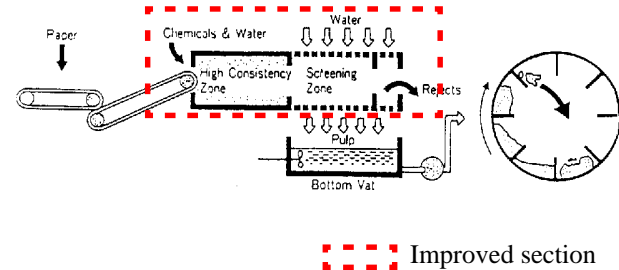


Table 1 Example of specification of drum-type high-concentration pulper

Model	FF-325
Treatment capacity	290 t/d (waste newsprint paper)
Dimension	Dia. 3.25 m x length 20 m
Driving power	355 kW
Rotation	13 rpm

Fig. 1 Schematic flow of drum-type high-concentration pulper

[Description]
Structure explanation, Shape, and/or System diagram

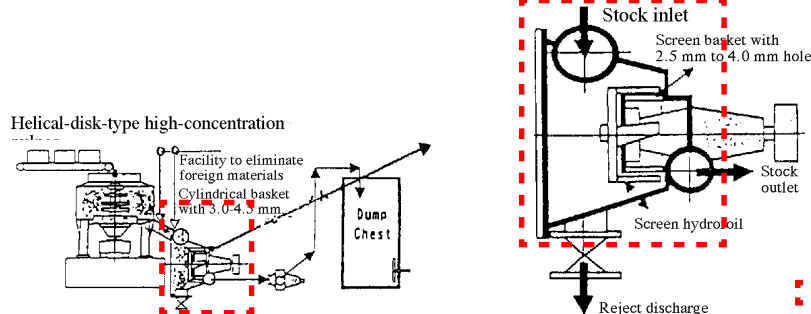


Fig. 2 Schematic diagram of rotary-type high-concentration pulper

Energy saving effects

Table 2 Comparison of energy-saving effects by conventional and helical-disk-type high-concentration pulpers

	Conventional high-concentration pulper	Helical-disk-type high-concentration pulper	Energy saving
Feed rate	5,400 kg/batch	6,000 kg/batch	
Pulper production	216 t/d	248 t/d	
Macerated stock concentration	15.4%	17.7%	
Specific power consumption	32.2 kWh/t	21.5 kWh/to	80% reduction
Power consumption	2,295,200 kWh/y	1,759,600 kWh/y	535,600 kWh/y (23%) reduction
Energy saving in crude oil equivalent			130 kL/y

[Economics]
Equipment cost
Specifications of the equipment; drum-type pulper, treatment capacity 250 BDt/d, 1 set of auxiliary equipment (including installation cost)
Cost of the equipment: about 500 million yen Investment payback (A/B): 2to 3 years

Remarks

[Example sites] Adopted at many sites.	[References] The Journal of Japan Technical Association of the Pulp and Paper Industry (Vol. 36, No. 1, 1982, P. 59; Vol. 51, No. 11, 1997, P. 49)	[Inquiry] Japan Paper Association / ECCJ (JIEC)
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PP-ME-1

Energy Conservation Directory

[Industry Classification] Paper & Pulp	High-temperature odorless heat recovery boiler	[Energy Source] Electricity, Steam
[Technology Classification] Machinery & Equipment		[Practical Use] 1983

Outline

This recovery boiler has dual purposes: 1) to burn the digester waste liquid (black liquor) of the chemical pulpmaking process, generate steam, and recover waste heat, and 2) to melt the inorganic chemicals (Na and S) used for digesting and recover them as smelt. In the conventional recovery boilers, the flue gas was directly contacted with the black liquor in the fuel gas duct to condense it. This process emitted disagreeable odors of sulfur and other compounds. Beside, the heat recovery was not sufficient so as not to cause corrosion by the flue gas, and the temperature of the generated steam could not be raised higher than 420°C. Development of the black liquor condensing technology using the high-temperature odorless recovery boiler has made it possible to receive highly concentrated black liquor, generate high temperature (more than 500°C) and high pressure (more than 100 Kg/cm²) steam, and solve odor problems. This has contributed to enhancement of the thermal efficiency and hence to improvement of the power generation efficiency.

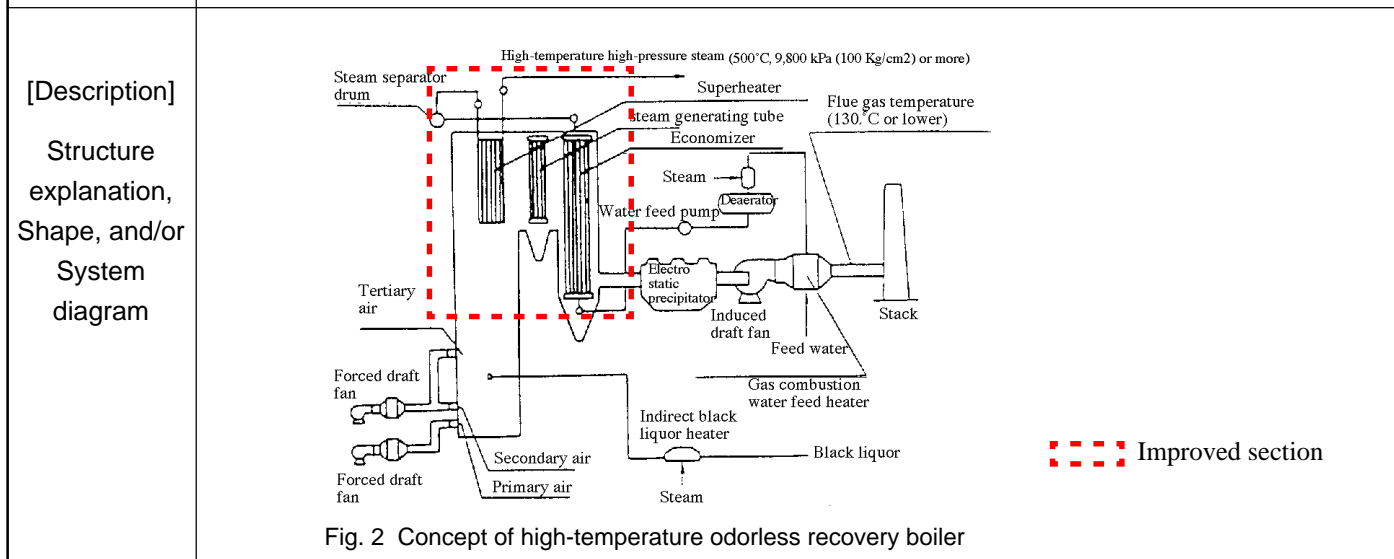
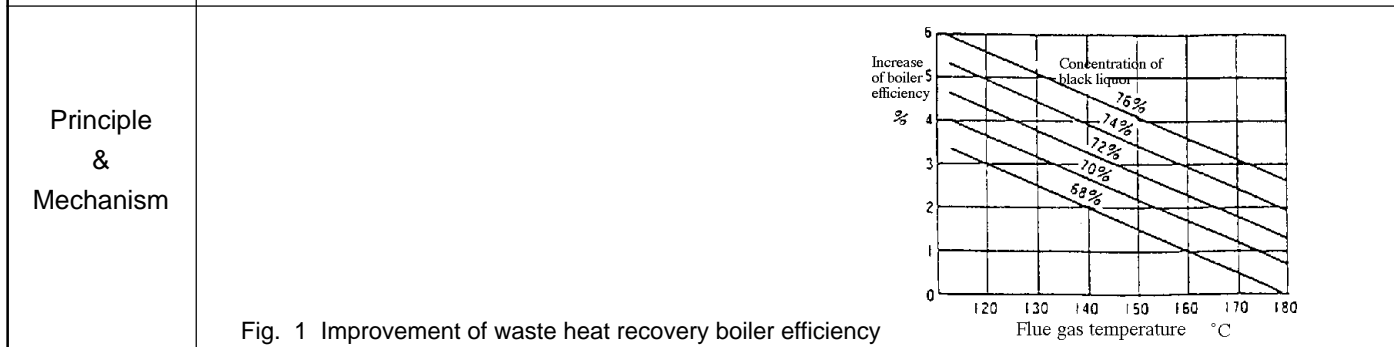


Table 1 Energy saving effect achieved by efficiency improvement of heat recovery boiler (150 tons/hour boiler, operation of 8,000 hours/year)

	Before improvement	After improvement	Improvement effect
Boiler efficiency	55%	75%	20% improvement (1.4 times improvement)
Reduction in crude oil equivalent			73,600 kL/year

[Economics]

Equipment cost

Investment amount(A): million yen
 Improvement effect (B): million yen/year
 Investment payback (A/B): years

Remarks

[Example sites]	[References] The Journal of Japan Technical Association of the Pulp and Paper Industry (Vol. 47, No.9, 1993, P. 50; Vol. 45, No.6, 1991, P. 14; Vol. 47, No.8, 1993, P. 51; Vol. 47, No.9, 1993, P. 44)	[Inquiry] Japan Paper Association / ECCJ (JIEC)
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PP-ME-2

Energy Conservation Directory

[Industry Classification] Paper & Pulp	Chemical pulp, plate-type multi-effect liquid-film evaporator for condensing black liquor	[Energy Source] Fuel (steam)
[Technology Classification] Machinery & Equipment		[Practical Use] 1970s

Outline

The multi-effect evaporator was used for condensing waste liquid from the cooking process of the chemical pulp manufacturing, or black liquor, to the highest concentration possible by evaporation. As the black liquor is concentrated, it rapidly becomes viscous and therefore the heat transfer coefficient becomes low. In addition, the boiling point rises. Therefore, forced circulation was employed in the final stage of the conventional multi-effect evaporation. Besides, an additional evaporator directly heated by the boiler flue gas was used to obtain the desired concentration. This evaporator suffers from deposit of hard scales on the tube inside, removal of which required a considerable manpower and time. The plate-type multi-effect liquid-film evaporator has been adopted to solve all these problems and to achieve a high degree of energy saving at the same time.

Principle & Mechanism

The principle of the multi-effect evaporator is as follows. The first stage condenses to some extent the black liquor by heating it using saturated steam. The second stage under a reduced pressure further condenses the black liquor by using the vapor from the first stage as heating medium, and the subsequent stages consecutively repeat the same operation. The vapor from the last stage is condensed by cooling. Thus, a large amount of water is vaporized by using a small amount of heating steam.

[Description]

Characteristics of the plate-type liquid-film evaporator

- 1) The black liquor flows down on a wide heat transfer surface in a form of film and therefore it can be condensed to a higher concentration.
- 2) The scale formed on the plate is easy to remove.
- 3) The temperature difference between stages can be made smaller than the conventional evaporator. Therefore, the number of stages of this type of evaporator can be more than that of the conventional one.
- 4) The evaporator vessel is partitioned in two or three compartments. Therefore the vessel may be cleaned without being placed entirely out of service, with only one component isolated for cleaning from the system one after another.

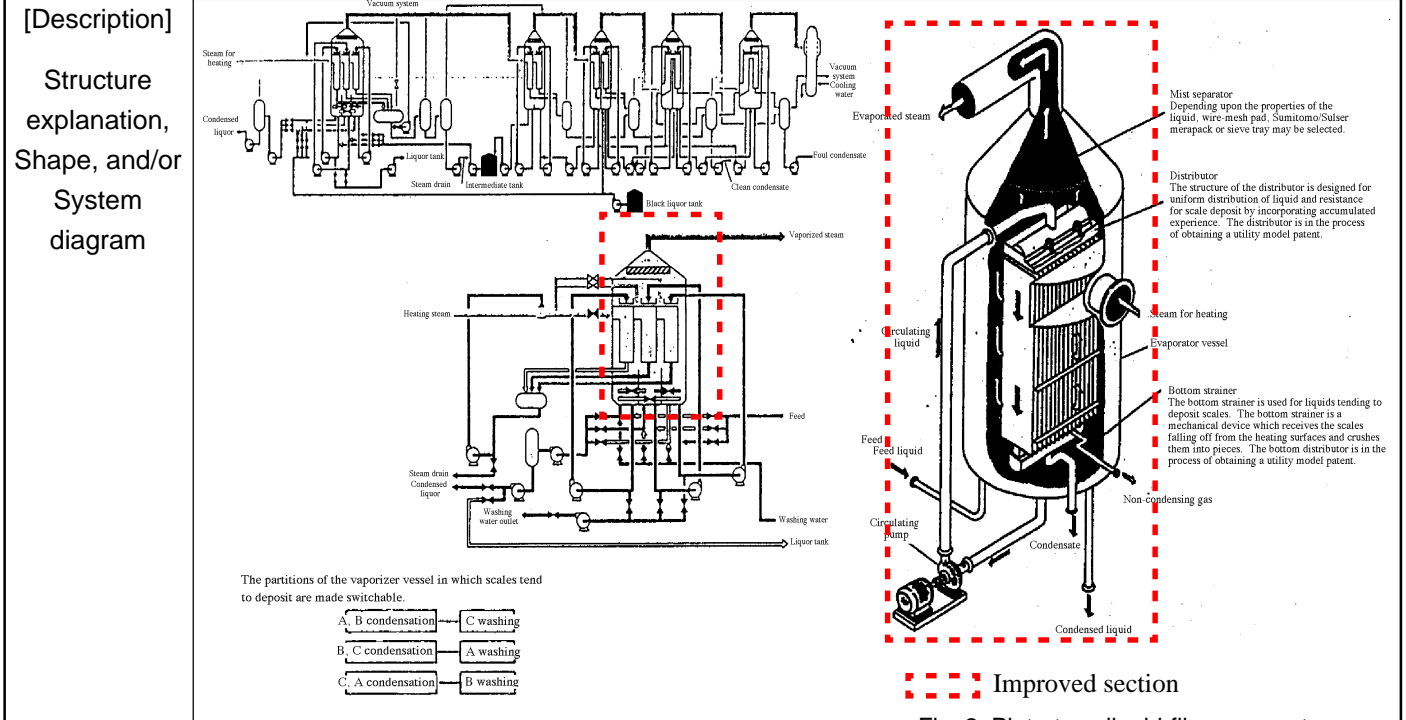


Fig. 1 KP Black liquor quintuple-effect five-vessel evaporator

Fig. 2 Plate-type liquid-film evaporator

Energy saving effects

Only this evaporator can increase concentration of waste liquid to 75 %. High concentration, together with the high-temperature odorless heat recovery boiler, solves odor problems in the KP plant and enables efficient use of energy.


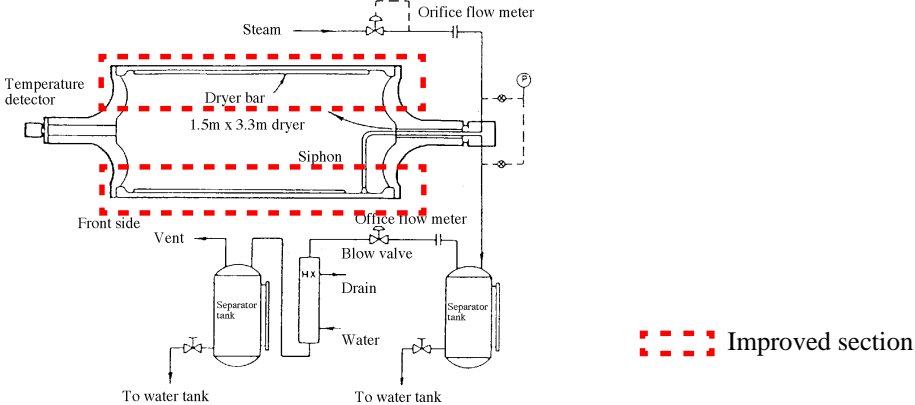
[Economics] Equipment cost	Investment amount (A): million yen	Improvement effect (B): million yen
	Investment payback (A/B): years	
	Pulp production: 500 tons/year	Solid substance in the black liquor: 800 tons/year
	Stage: Sextuple cost: about 850 million yen	

Remarks

[Example sites]	[References] The Journal of Japan Technical Association of the Pulp and Paper Industry (Vol. 33, No.1, 1979, P. 42)	[Inquiry] Japan Paper Association / ECCJ (JIEC)
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PP-ME-3

Energy Conservation Directory

<p>[Industry Classification] Paper & Pulp</p>	<p>Dryer with dryer bars installed inside for paper-making machine</p>		<p>[Energy Source] Fuel (steam)</p>
<p>[Technology Classification] Machinery & Equipment</p>			<p>[Practical Use] 1973 -</p>
<p>Outline</p>	<p>When a paper-making machine is run faster than 300 m/min., steam condensate in dryer drums covers the entire inside surface of the dryer drums and heat transfer is reduced. This phenomenon is known as rimming (Fig. 1). In order to increase the heat transfer efficiency and save energy consumption by a high-speed paper-making machine, a number of fixed siphon tubes, called dryer bars, are installed inside of the dryer drums.</p>		
<p>Principle & Mechanism</p>	<p>[Relationship between the paper-making machine speed and increase in the heat-transfer resistance of the dryer drum] - Speed of 300 m/min.: 15% of the total heat-transfer resistance - Speed of 1,000 m/min.: 40% of the total heat-transfer resistance [Relationship between the number of bars and optimum drain depth] - When the number of bars is 25, the optimum depth is 3.8 mm. (The height of a bar is about 10 mm.)</p> <div style="text-align: center;">  <p>Pond state Droplet state Rimming state</p> </div> <p style="text-align: center;">Fig. 1 State of steam condensate in the dryer drum</p>		
<p>[Description] Structure explanation, Shape, and/or System diagram</p>	<ol style="list-style-type: none"> 1) 15 to 30 pieces of bars (siphon tubes) are attached to the inside surface of the dryer drum in a ring form at fixed intervals along the axial direction. The cross-sectional area of a bar is about 6 cm². 2) The steam condensate existing between the bars is maintained in the state of turbulent flow with the rotation of the drum and the heat transfer is maintained high. 3) The bars are fixed in a ring form in direct contact with the inside surface of the dryer drum. <div style="text-align: center;">  </div> <p style="text-align: center;">Fig. 2 Schematic structure of dryer and flow diagram with associated devices</p>		
<p>Energy saving effects</p>	<p>[Example cases] 1) For coated paper material Paper-making machine width 4.6 m, weight 41 g/m², design speed 975 m/min. By installing 25 bars on one-third of the dryers, productivity is increased by 20% and specific steam consumption is decreased by 20%. 2) For Kraft liner (paper-making machine width 8.7 m) Operating condition: weight 160 g/m², speed 545 m/min.; weight 205 g/m², speed 460 m/min. By installing 25 bars on all the dryers, productivity is increased by 15% and specific steam consumption is decreased by 15%.</p>		
<p>[Economics] Equipment cost</p>	<p>Specifications of the equipment : Paper-making machine width 4.8 m, Number of dryers: 42 Cost of the equipment : Dryers 0.6 to 1 million yen per unit, Total cost : 21 million yen Improvement effect : 30 million yen/year Investment payback (A/B) : 0.5 to 0.7 year</p>		
<p>Remarks</p>			
<p>[Example sites] Verified at many sites.</p>	<p>[References] Makers' catalogs and technical documents</p>	<p>[Inquiry] Japan Paper Association / ECCJ (JIEC)</p>	

PP-ME-4

Energy Conservation Directory

[Industry Classification] Paper & Pulp	Installation of steam-recompression heat pump on paper-making dryer	[Energy Source] Fuel (steam)
[Technology Classification] Machinery & Equipment		[Practical Use] 1980s -

Outline
This improvement is an example of energy saving achieved by reusing steam after recompressing it. The hood on the dryer part of the paper-making machine is sealed to effectively recover the steam. The steam is then recompressed (VRC, MRC) by a screw compressor and reused.

Before Improvement
In paper making, wet paper is indirectly heated and dried while it continuously runs on a series of hot rotating drums (cylinders). These drums are heated by steam introduced inside them. To purge the evaporated moisture out of the system, a certain amount of hot air is introduced into the drying system as carrier gas. This causes excessive air to enter the system, which increases the wasteful consumption of heating steam.

[Description of Improvement]

Structure explanation, Shape, and/or System diagram

- When the air volume in the carrier gas increases, the dew point of the exhaust gas significantly lowers, and the temperature at which waste heat is recovered from the exhaust gas comes down. This reduces the coefficient of performance (COP) of the heat pump. This system controls the flow rate of carrier gas so that the air volume in the exhaust gas is maintained at about 13.5 vol%; at this air volume the dew point is 96°C. The hood on the dryers is sealed to minimize the leakage of air from outside.
- The exhaust gas from the dryer is introduced into a packed-tower condenser in which the exhaust gas contacts the circulating water flowing countercurrent to the gas. The temperature of the circulating water is heated from 90.5°C to 94°C. The circulating water is flashed into the flash tower in which water partially vaporizes under reduced pressure. The circulating water is recycled back to the condenser top.
- The steam generated in the flash tower is drawn by the compressor at 0.73 Kg/cm²A (saturation at 90.5°C) and compressed to 3.0 Kg/cm²A (saturation at 132.9°C) to be used as heat source for the dryer.

Fig. 1 Flow diagram of steam-recompression heat pump system applied to drying process in paper making

Table 1 Energy-saving effect of VRC-type heat pump system

	Before improvement	After improvement	Effects
Steam consumption	1.6 t/h	-	604,500 kcal/h (8,000 h/y)
Electric power consumption	-	158 kW/h	
Energy saving in crude oil equivalent			1,175 kL/h

[Economics]
Equipment cost
 Investment amount (A): million yen
 Improvement effect (B): million yen/year
 Investment payback (A/B): years

Remarks
The present case represents an application of steam recompression to the drying process in the pulp and paper industry. This technology is applicable to chemical or food processing industry as well, and is extensively employed.

[Example sites] Many applications in similar drying processes	[References] Energy Saving Journal (Vol. 37, No.10, 1985, P. 79)	[Inquiry] Japan Paper Association / ECCJ (JIEC)
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PP-ME-5

Energy Conservation Directory

[Industry Classification] Paper & Pulp	Mechanical pulp manufacturing process, heat recovery from thermomechanical pulp (TMP)	[Energy Source] Electricity
[Technology Classification] Machinery & Equipment		[Practical Use] 1992

Outline
Thermomechanical pulp (TMP), a representative mechanical pulp, is manufactured by grinding and reducing wood chips in the refiner after preheating them at 115 to 125°C. Operation of the refiner consumes a large amount of electric power, a large one consuming as much as several tens of thousands of kilowatts. The electric power consumed is converted into heat. The present technology is to recover the heat thus generated.

Principle & Mechanism
[Two-stage refining system] (Refer to Fig. 1.)
The TMP refiner normally processes wood chips in two stages; under pressurized condition and under atmospheric condition.

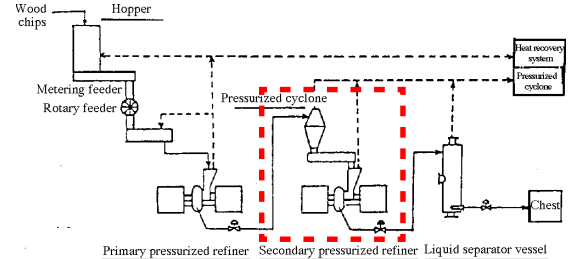


Fig. 1 Two-stage pressurized refiner system

[Description]
Structure explanation, Shape, and/or System diagram

- Heat recovery is done by taking exhaust steam at around 100°C and using it for heating water in a heat exchanger, or by injecting the waste steam into the white liquor to be used in other processes to warm it.
- Another method for utilizing this waste steam is to take clean low pressure steam and use it in the drying process in papermaking. In this method low pressure steam is withdrawn from the pressurized cyclone for treating the blowout from the primary refiner. A heat pump or evaporator is used to generate clean steam from the steam separated from the cyclone.
- Generation of waste steam is 0.8 to 0.9 tons per ton of pulp, converted to the 100°C and atmospheric pressure condition, from the primary stage refiner. This amount corresponds to two-thirds of the electric power consumption of the TMP process. The secondary refiner produces 1.3 times as much steam as the primary refiner.

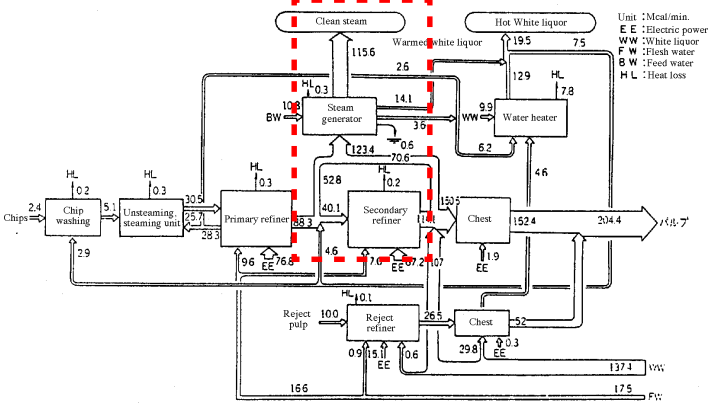


Fig. 2 Energy balance of refining system (TMP 150 AD t/day)

Table 1 Energy saving effect by TMP heat recovery

Energy saving effects	Before improvement	Effect
Reduction in specific consumption by steam recovery	1.0 to 1.1 t/(t-pulp)	Reduction of steam by 54,450 t/y
Reduction in crude oil equivalent		4,440 kL/y

[Economics]
Equipment cost
Investment amount (A): 70 million yen
Improvement effect (B): 70 million yen/year
Investment payback (A/B): 1 year

[Remarks]
The exhaust steam contains minute fibers. The exhaust steam from the primary refiner, in particular, contains such impurities as volatile substances at high contents. Besides, the condensate is acidic at pH values of 2.5 to 4. The steam generator should incorporate self-cleaning function to facilitate washing.

[Example sites]	[References] The Journal of Japan Technical Association of the Pulp and Paper Industry (Vol. 40, No.4, 1986, P. 22; Vol.47, No.4, 1993, P. 36)	[Inquiry] Japan Paper Association / ECCJ (JIEC)
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PP-ME-6

Energy Conservation Directory

[Industry Classification] Paper & Pulp	High efficiency dehydrator for dryer of paper-making machine	[Energy Source] Electricity
[Technology Classification] Machinery & Equipment		[Practical Use] Around 1985

Outline
The consumption of steam for paper drying can be substantially economized by preliminarily dehydrating the wet paper web at the point of leaving the Fourdrinier paper machine before being sent to the drying section. The traditional rolling press dehydrator relies on linear pressure. The present modified shoe press enhances the dehydration effect by applying a high pressure on some area of the paper web, thereby saving steam in the subsequent drying section.

Principle & Mechanism
One percent reduction of moisture by the shoe press dehydrator at the inlet of dryer part can reduce steam consumption by five percent at this part.

<p>[Before modification] Conventionally, the wet paper web was dehydrated by pressing it between two rolls. The pressure is applied only on a line of shortest clearance between the rolls and therefore dehydration effect was low.</p>	<p>[After modification] The modified extended-pressing dehydrator has a wider pressing area between the rotating roll and the pressing shoe. The wet paper web is squeezed under high pressures over a prolonged time. The combined effects of these two substantially improve the dehydration effect.</p>
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[Description]
[Structure of the extended-pressing dehydrator] (Refer to Figs. 1 and 2.)

- 1) The shoe presses come in two different types, open-type as shown in Fig. 1 and roll-type as shown in Fig. 2. The open-type roll press has problems with oil spattering and erosion. Today, only the non-oil-leaking roll-type press is used. In the roll-type press, the shoe may be attached either upside or downside the nip.
- 2) Force of pressing the shoe on the facing roll, or the crown control roll, is controlled hydraulically. (Refer to Fig. 3.)
- 3) The nip is normally 250 millimeters wide. The nip pressure may be raised to 1,500 kN/m, while in the conventional roll press the pressure is limited to 400 kN/m. When processing the paper for making corrugated fiberboard (Kraft liner and likes), operation of the roll press is suspended and two stage shoe presses are employed.

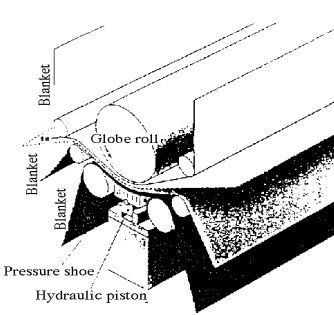


Fig. 1 Open-type shoe press

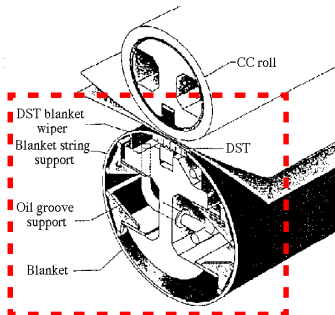


Fig. 2 Roll-type shoe press

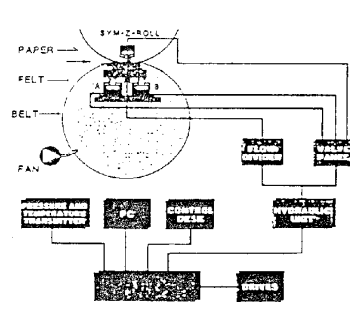


Fig. 3 Shoe press pressure control system

Table 1 Energy saving effect of high-pressure dehydrator

(Dehydration condition)		Before improvement (Roll press)	After improvement (Shoe press)	Effect
Water content 62% to 56%	Specific steam consumption	2.3 t/T (paper)	1.7 t/T (paper)	Reduction of 0.6t/T (25%)
Reduction in crude oil equivalent		(Reduction of steam : 90,000 t/y)		7,338 kL/y

[Economics]
Equipment cost
Specification of the facilities:
Paper making machine consists of a shoe press for Kraft liner 5.4 meters wide (in case of making fiberboard for corrugated fiberboard), a crown roll, and a set of controlling system, costing about 560 million yen.
Investment payback : 1 year

[Example sites]	[References] The Journal of Japan Technical Association of the Pulp and Paper Industry (Vol.39, No.1, 1985, P. 133; Vol.51, No.1, 1997, P. 171; Vol.51, No.2, 1997, P. 80; Vol.51, No.11, 1997, P. 82)	[Inquiry] Japan Paper Association / ECCJ (JIEC)
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PP-ME-7

Energy Conservation Directory

[Industry Classification] Paper & Pulp	Heat recovery by sludge incinerator	[Energy Source] Electricity, Fuel
[Technology Classification] Machinery & Equipment		[Practical Use] Late 1980s

Outline This technology consists in improving energy conservation efficiency by recovering exhaust heat from the fluidized-bed incinerator for burning sludge discharged from the papermaking process of paper mills.

Before Improvement Traditionally, most paper mills have disposed of sludge and solid wastes by landfilling. Final disposal facilities for sludge and solid wastes are becoming hard to secure. Besides, these sludge and solid wastes contain combustible substances at high contents. Under such a circumstance, recovery of exhaust heat from incineration is desired.

[Description of Improvement]

[Outline of the process] (Refer to Fig. 1.)

- Such wastes as sludge, rags and ropes are pretreated by the crusher and screw press before being fed to the fluidized-bed incinerator.
- The wastes fed to the incinerator are vigorously agitated with the bed material at temperatures between 700 and 800°C and burn.
- The combustion gas leaves the incinerator at 800 to 900°C and is cooled by the exhaust heat boiler to 350 to 400°C while generating steam to be used in the paper mill. Thereafter, the exhaust gas exchanges heat with the feed air to the incinerator in the air preheater where the exhaust gas is cooled to about 200°C. The exhaust gas is discharged from the stack after being treated by the bag filter for removal of soot and dust.
- SOx and HCl are removed by injecting calcium carbonate in the furnace of the incinerator.
- This incinerator achieves both control of NOx emission and complete combustion by two-stage

Structure explanation, Shape, and/or System diagram

[Major equipment specifications] (One example)

- Incinerating capacity: 95 BDt/D
- Capacity of the combustion chamber: 145 m³
- Boiler
- Steam generation: 16.8 t/h
- Pressure: 19 Kg/cm²g max.

Fig. 1 Paper mill sludge and solid wastes fluidized-bed incinerator ■■■■ Improved section

Energy saving effects

Table 1 Energy saving effect of waste heat recovery

	Effect	Note
Steam recovery	16,800 kg/h	Treated waste 95t/D
Heat recovery	11,145,000 kcal/h	
Energy saving - crude oil equivalent*	9,543 kL/y	

Note: * Operation 24h/D and 330 D/y

[Economics] Equipment cost Investment amount (A): 1,000 million yen
Improvement effect (B): 170 million yen/year
Investment payback (A/B): 6 years

Remarks This technology will be demonstrated by the New Energy and Industrial Technology Development Organization (NEDO) of Japan as a model project, "Facility for effective utilization of such wastes as sludge in the paper mill in Indonesia" in the Fajar Paper Mill in Indonesia, scheduled to be completed in March 2001.

[Example sites]	[References] NEDO Report	[Inquiry] Japan Paper Association / ECCJ (JIEC)
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PP-ME-8

Energy Conservation Directory

[Industry Classification] Paper & Pulp	Re-powering system and gas turbine exhaust heat boiler	[Energy Source] Electricity
[Technology Classification] Machinery & Equipment		[Practical Use] 1993-

Outline The paper industry was ahead of other industries in adoption of re-powering of gas turbines. The present case utilizes energy in multi-stage in a cascade fashion, thereby achieving from 10 to 30 percent energy saving. Aside from re-powering, an increasing number of paper mills are adopting exhaust gas boilers together with gas turbines.

Principle & Mechanism The re-powering system is, by definition, to add (a) gas turbine(s) to the existing steam boiler/turbine system (BTC) to increase the power generation capacity and at the same time to raise thermal efficiency.

[Description] [Flow of the gas turbine re-powering system] (Refer to Fig. 1.)
This system consists of the existing boiler and steam turbine and the added gas turbine. The exhaust gas from the added gas turbine is conducted to the existing boiler to assist heating it to enable the existing steam turbine to run on the rated capacity. Therefore, the power generation increases by the delivery of the added gas turbine.

Structure explanation, Shape, and/or System diagram

[] Improved section

Fig. 1 Example of gas turbine re-powering system

Table 2 Energys saving effect of the gas turbine re-powering system

	Before modification	After modification (After introduction of re-powering system)
Energy saving rate		14.5% reduction of input energy
Emission of NOx and CO ₂		30% reduction
Heat balance (Input to the traditional system being 100%)	<p>Traditional system</p>	<p>Repowering system</p>

[Economics] Equipment cost Specifications of the facilities Output of turbine: 1,700 kW Modification of the existing boiler for gas burning
Cost of facilities:

Remarks The gas turbine exhaust gas boiler system needs installation of a new boiler to use exhaust heat of the gas turbine. Since the temperature of the exhaust gas is relatively low, steam generation is low in spite of a large volume of the exhaust gas. Well balanced operation of the existing boiler and the turbine is important.

[Example sites]	[References] The Journal of Japan Technical Association of the Pulp and Paper Industry (Vol.49, No.1, 1995, P. 114; Vol.51, No.11, 1997, P. 10)	[Inquiry] Japan Paper Association / ECCJ (JIEC)
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PP-ME-9

Energy Conservation Directory

[Industry Classification] Paper & Pulp	Use of medium-concentration chemical mixer in the oxygen delignification and bleaching processes for manufacturing chemical pulp	[Energy Source] Electricity
[Technology Classification] Machinery & Equipment		[Practical Use] 1993-

Outline
The pulp fibers have a very high water holding capacity; therefore, the conventional centrifugal pumps were used to deliver pulps at a low concentration of about 3 percent. In the beginning of the 1980s, high-shear mixers were developed which could be used for transportation of the raw material and chemicals and also for mixing pulp at medium concentrations of from 8 to 13 percent. This enabled an integrated operation of the plant beginning with the medium concentration slurry. In 1988 a compact but highly efficient mixer was commercialized and it has contributed greatly to energy saving.

Principle & Mechanism
- Structure of the compact high-efficiency mixer, unlike the traditional ones, is so designed that the high-shear mixing space is very small; in other words, power input per unit volume is made high enough to enhance mixing effect.
- Chemicals can be mixed either in liquid form or gas form. A special disperser is used for certain chemicals.

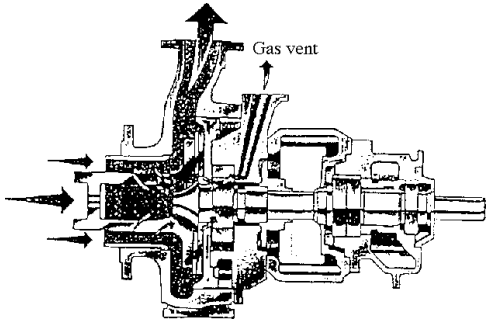
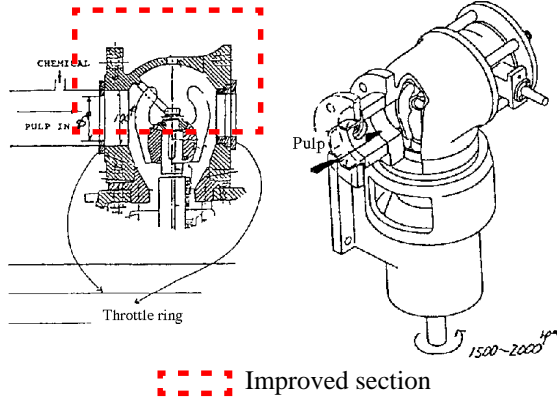
[Description] Structure explanation, Shape, and/or System diagram	[High-shear mixer for medium concentration pulp]	[Compact high-efficiency mixer]
	 <p>Fig. 1 High-shear mixer for medium concentration pulp</p>	 <p>Fig. 2 Compact high-efficiency mixer</p>

Table 1 Energy saving effect of the compact high-efficiency mixer

	Medium concentration mixer	Compact high-efficiency mixer	Energy saving effects
Specific consumption of electric power	4.1 kWh/t	0.8 kWh/t	80% Reduction
Consumption of electric power*	676,500 kWh/y	132,000 kWh/y	Reduction of 544,500 kWh/y (80%)
Energy saving - crude oil equivalent			132 kL/y

Note: * Production at 500 tons/day and 300 days/year operation

[Economics] Equipment cost
- Specifications of the facility
Pulp production: 300 tons/day
High-shear mixer for medium concentration pulp: 1 unit, 100 kW
Cost of facility: Mixer unit only, about 6 million yen
- Specifications of the facility
Pulp production: 500 tons/day
Compact high-efficient mixer: 1 unit
Cost of facility: Mixer unit only, about 12 million yen
Investment payback: 1 year

[Remarks]
Materials of key parts are titanium, hastelloy C and ceramics.

[Example sites]	[References] The Journal of Japan Technical Association of the Pulp and Paper Industry (Vol.37, No.2, 1994, P. 5) Makers' catalogs	[Inquiry] Japan Paper Association / ECCJ (JIEC)
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[Industry Classification]
Paper & Pulp

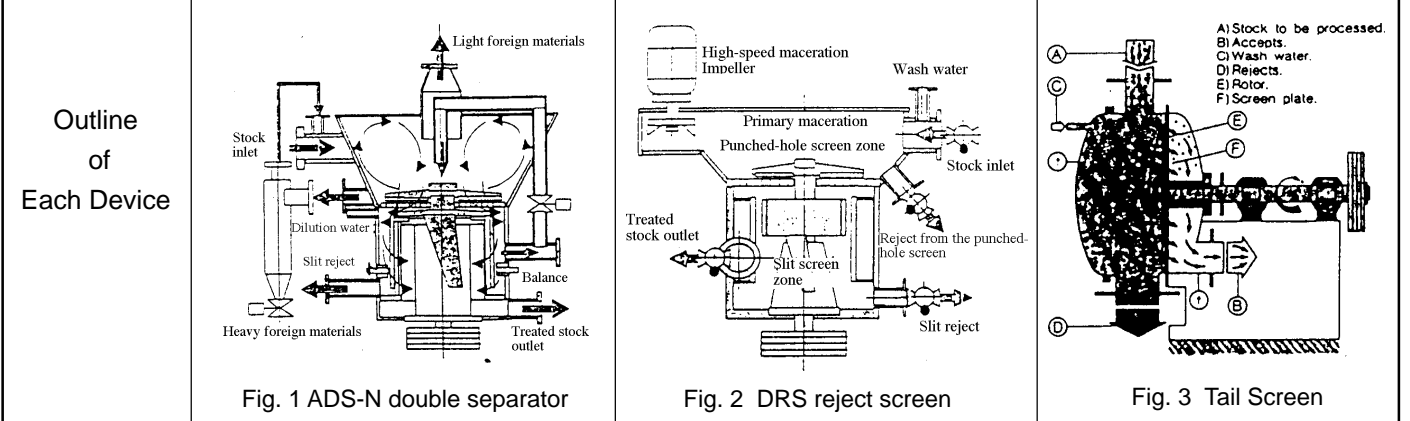
Integration of punched metal screen, slit screen and maceration machine for processing waste paper

[Energy Source]
Electricity

[Technology Classification]
Machinery & Equipment

[Practical Use]
1980s -

Outline
In the preliminary classification process of waste fiberboard and de-inked waste paper, screening operation, maceration of the reject from the screening operation, and further screening were processed by separate equipment. The present improvement integrates all these operations into a single unit, thereby dispensing with pumps, tanks, and agitators that were needed between these operations. This realizes a shorter operation period and energy saving.



[Description]
Fig. 4 shows a system of waste-paper treatment which combines the ADS-N double separator, DRS reject screen and tail screen (punched-hole Jambo refiner).

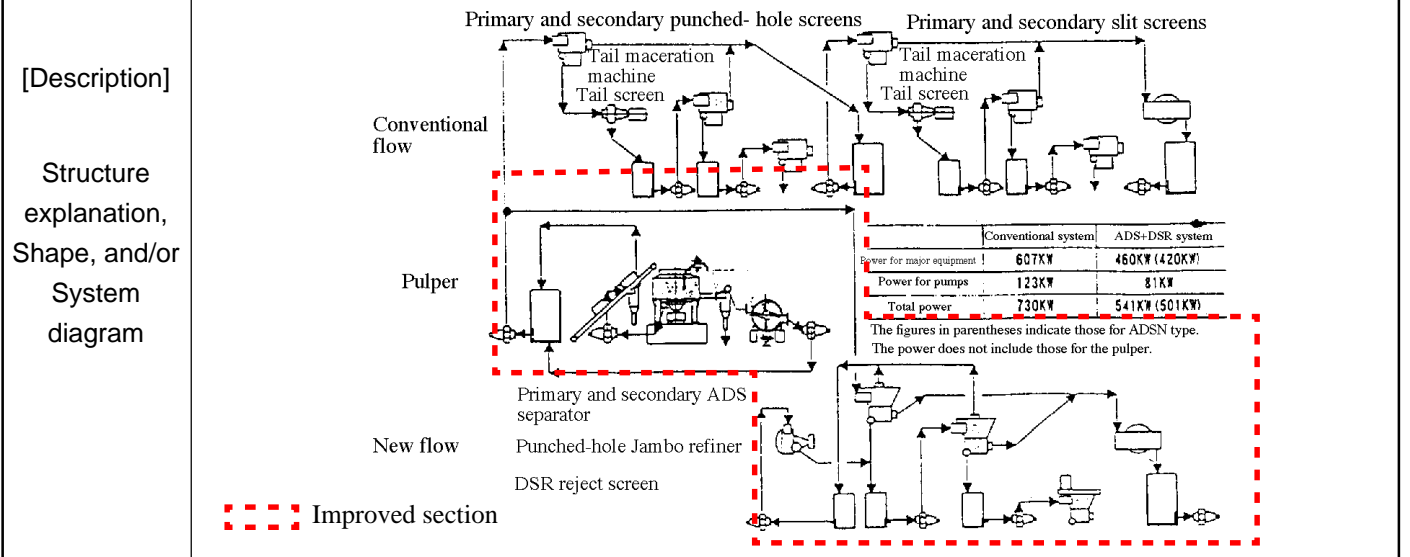


Fig. 4 Schematic flow for treating waste fiberboard by integrated screen (production 250 t/d)

Table 1 Energy saving effect of the integrated screen system

Energy saving effects	Conventional system	Improved system (primary and secondary screens integrated)	Effects
Capacity of A- series equipment	730 kW	541 kW	Reduction by 26 to 31%
Capacity of B- series equipment		501 kW	

[Economics]
Equipment cost: Investment cost :735 to 885 million yen Improvement effect : 60 million yen/year
Investment payback ; low equipment costs and significant improvement

Remarks

[Example sites]
Adopted at many sites.

[References]
The Journal of Japan Technical Association of the Pulp and Paper Industry (Vol. 51, No. 11, 1997, P. 49; Vol. 46, No. 12, 1992, P. 49)

[Inquiry]
Japan Paper Association / ECCJ (JIEC)

PP-ME-11

Energy Conservation Directory

[Industry Classification] Paper & Pulp	Multi-functional combined screen for waste paper processing	[Energy Source] Electricity
[Technology Classification] Machinery & Equipment		[Practical Use] 1994

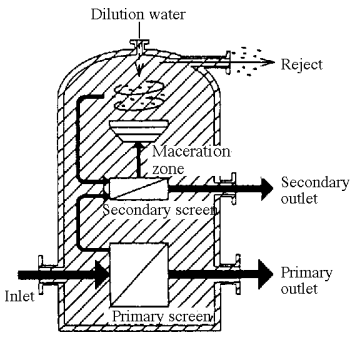
Outline
 One of the problems with the waste paper screen is that the yield at the pulper is reduced if its separation effect is increased, as more unmacerated fibers are rejected.
 This improvement is to operate the primary and secondary screens at high rejection rates; however, a high internal recycle rate is maintained between both screens, thereby achieving a high rate of separation and a high yield at the same time.

[Description]

- MF-type multi-functional slit screen (Fig. 1)
 - The reject rates of the primary screen and the secondary screen are high at 30-35% and 40-50%, respectively. Both screens have separate outlets.
 - Maceration is done by liquid shear force rather than by mechanical shear force, the former being weaker than the latter; therefore, power consumption for maceration is held low.
- MFC-type multi-functional punched-hole screen (Fig. 2)
 - The punched-hole screen is intended solely for coarse separation. It consists sequentially of the main screen, maceration zone, and auxiliary screen.
 - The well-macerated waste paper exists from the single product outlet. The mechanism of maceration is the same as that of the slit screen; however, maceration performance is greatly improved.

Structure explanation, Shape, and/or System diagram

(a) Conceptual view of internal structure



(b) Cross-sectional drawing

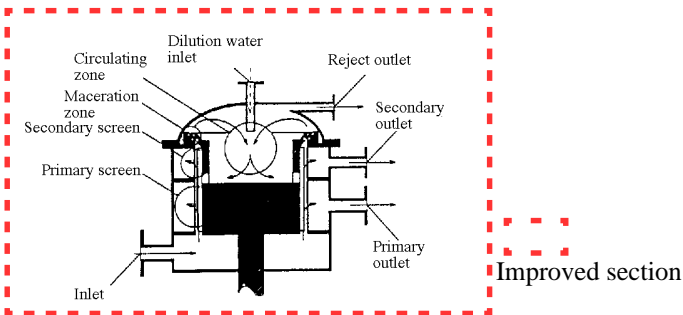
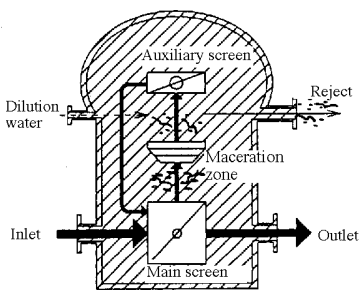


Fig. 1 Multi-functional screen (MF-type slit screen)

(a) Conceptual view of internal structure



(b) Cross-sectional drawing

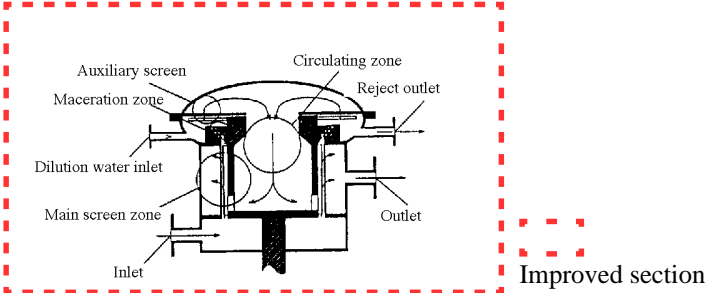


Fig. 2 Multi-functional punched-hole screen (MFC-type)

Energy saving effects	1) Punched-hole screen 2) Slit screen	Electric power saving rate, %: 24.2 to 58.5 Electric power saving rate, %: 39.3 to 70.2
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[Economics] Equipment cost
 Specifications : Treating capacity 250 t/D, equipment only
 Cost : 35 million yen (The conventional system costs 50 million yen.)
 Improvement effect : 7 million yen/year
 Investment payback : 2 years

Remarks

[Example sites] There are more than 100 cases of commercial application.	[References] The Journal of Japan Technical Association of the Pulp and Paper Industry (Vol. 50, No. 8, 1996, P. 81; Vol. 51, No. 1, 1997, P. 31; Vol. 51, No. 11, 1997, P. 63; Vol. 52, No. 4, 1998, P. 55)	[Inquiry] Japan Paper Association / ECCJ (JIJC)
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[Industry Classification] Paper & Pulp	Energy saving in crown controlling roll	[Energy Source] Fuel, Electricity
[Technology Classification] Machine & Equipment		[Practical Use] The mid 1980s -

Outline
The papermaking machine employs crown rolls in the squeezing press to dehydrate the paper web and also in the calendering press to make paper smooth and glossy. The operation of crown rolls is hydraulically controlled. The power for crown roll operation is consumed mostly by the friction of the shoes and agitation of oil. The energy saving crown controlling roll has been developed to reduce these losses.

Principle & Mechanism
[Measures to reduce power loss in the hydraulic device of the crown controlling roll]
- Dividable shoes were employed to make the pressuring part inside the roll non-contacting to reduce the friction loss.
- A hydraulic oil of low viscosity was adopted to reduce friction loss associated with oil agitation.

[Description]
[Structure and features of the crown controlling roll]
1) The crown controlling roll controls the crown hydraulically by the hydraulic shoe placed inside the roll on the nip. The nip used to be of a one-piece structure over the entire width of the roll. In the case of the energy saving roll, a modification had been made to divide the shoe into a number of pieces arranged along the width, each piece controlling the pressure on its respective zone. (Refer to Fig. 1.) The pressuring parts inside the roll have been made non-contacting, which substantially reduced the power consumption.

Fig. 1 Crown controlling roll (Zone-controlling type)

2) The roll shell is of self-loading type; in other words, it may be vertically adjusted independent of the fixed roll shaft as shown in Fig. 2. This realized flat nip of high precision that was difficult with the one-piece shoe.

Fig. 2 Mechanism of self-loading

Table 1 Energy saving effect of the crown control roll

		Before modification	After modification	Effects
Reduction of friction loss	Shoe	325 kW	164 kW	(Reduction from 500 kW to 289 kW), Reduction of 211 kW (42%)
	Oil agitation	100 kW	50 kW	
	Nip bearing	75 kW	75 kW	
Energy saving - crude oil equivalent		(Power consumption: 1,519,200 kWh)		Reduction of 369 kL/y

Note: * Operation of 24 hours/day at 300 days/year.

[Economics] Equipment cost
Specifications of the facility: Width and length of the roll are 7 meters and 900 millimeters, respectively.
Cost of the facilities: about 50 million yen
Improvement effect : 14million yen/year
Investment payback : 4 years

Remarks

[Example sites]	[References] Makers' catalogs and documents	[Inquiry] Japan Paper Association / ECCJ (JIEC)
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PP-ME-13

Energy Conservation Directory

[Industry Classification] Paper & Pulp	High-temperature soft calender for paper making	[Energy Source] Electricity
[Technology Classification] Machinery & Equipment		[Practical Use] Around 1985 -

Outline
A high-temperature soft calender is a highly efficient machine to calender the feed paper on line in a paper-making machine when applying light coating or manufacturing light-weight coated paper. In comparison with a conventional independent calendering machine, it can realize substantial energy saving.

Principle & Mechanism
The high-temperature soft calender consists of a metal roll with a crown control device and a pressurizing soft roll covered with a relatively soft elastic material. The calender makes the coated paper smooth and glossy at a temperature of about 140°C. A pair of calenders are used to treat both the front and rear surfaces of the paper.

[Description]
The cross section of a pressurizing soft roll is shown in Fig. 1. Fig. 2 is the schematic structure of the facility.

Structure explanation, Shape, and/or System diagram

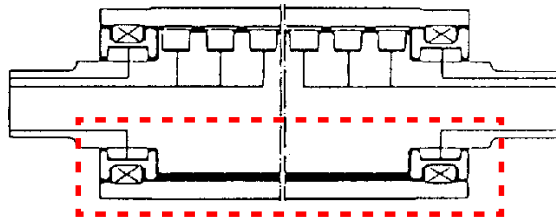


Fig. 1 Soft roll covered with elastic material

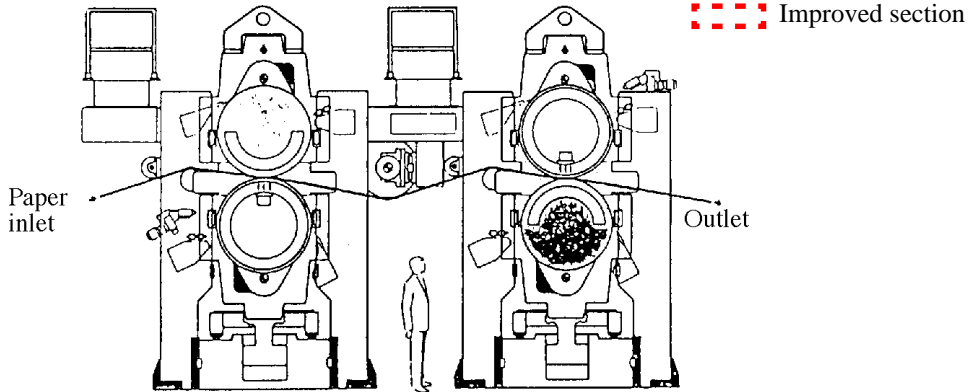


Fig. 2 High-temperature soft calender facility

Energy saving effects

Table 1 Comparison of power consumption by conventional calender and high-temperature soft calender (for paper-making machine with wire width of 3.6 m)

	Conventional calender	High-temperature soft calender	Effects
Power requirement	550 kW	330 kW	
Power reducing effect (in percentage)	100	60	40% reduction

[Economics] Equipment cost
Investment amount (A): 250 to 620 million yen
Improvement effect (B): 62 million yen/year
Investment payback (A/B): 6 years

Remarks
Aramid resin and similar substances are used as the elastic cover of the roll.

[Example sites] Adopted at many sites.	[References] Makers' in-house technical documents	[Inquiry] Japan Paper Association / ECCJ (JIEC)
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PP-ME-14

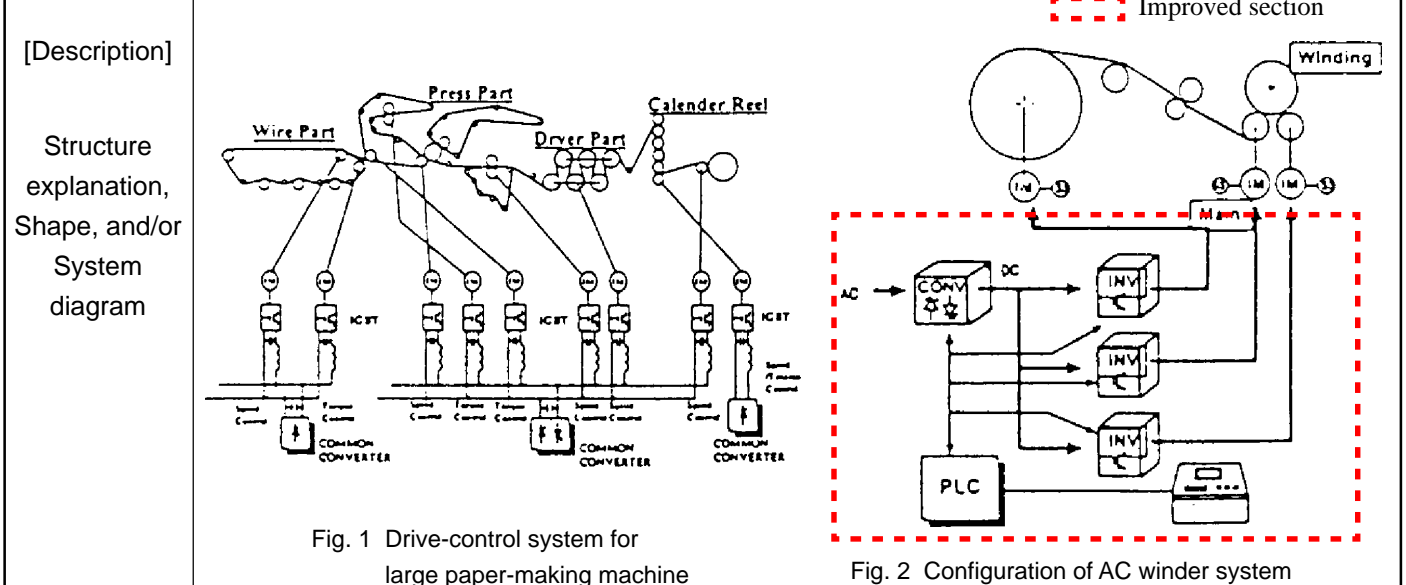
Energy Conservation Directory

[Industry Classification] Paper & Pulp	Adoption of AC Driving for Papermaking Machine and Winder System	[Energy Source] Electricity
[Technology Classification] Machinery & Equipment		[Practical Use] 1980s

Outline
The paper web fed to the papermaking machine is elongated by from 6 to 10 percent over the entire course from the wire part to the final rolling. Therefore, driving speed at each part must be minutely controlled. Formerly, the direct-current (DC) motors plus SCR were used. Recently, more energy efficient alternating-current (AC) motors with inverter control has become common.

Principle & Mechanism
History of drivers for papermaking machines and winders
Before 1960: Commutator motors, DC motors
After the 1960s: AD to DC conversion with SCR
After 1976: Inverter-controlled AC motors

[Description]
1) Fig. 1 shows a totally AC driving system for papermaking machine. It may be noted that inverter control is extensively employed with GTR and GTB elements.
2) Fig. 2 shows a winder system. The winder is driven independently of the papermaking machine. Because of its large power requirement, conversion to AC driving lagged behind the papermaking machine. The advent of the inverter has made it easier to use AC driving.



Energy saving effects

1) Energy saving effect of the conversion of papermaking machine driving system

- Conversion from the commutator motors, DC motors into the SCR system: about 20 to 25 percent energy saving effect
- Conversion from the SCR system to the totally-AC motor driving system: 4 to 6 percent reduction (Associated effect: The latter system is superior to the former in accuracy of control and ease of maintenance; these combined improves energy efficiency.)

2) Energy saving effect of the conversion of winder driving from the DC system to the AC system

Table 1 Comparison of Power loss of DC system and AC system

	DC system [A]	AC system [B]	Loss difference ([A] - [B])
Power loss	WD loss : 20.2kW	WD loss : 11.1kW UD loss : 2.2kW Converter loss : 0.65kW	[A] - [B] ~ 181kW
Other loss	22.8kW or more	8.73kW or more	
Brake loss	174kW		

[Economics]
Equipment cost
Specifications of the winder, Driver and controlling facilities:
Speed, 2,300 meters/min.
Output of the motor for winder, 290 kW
Output of the motor for sheeting, 310 kW
Cost of the facilities: About 100 million yen including installation
Improvement effect : 12 million yen Investment cost : 8 years

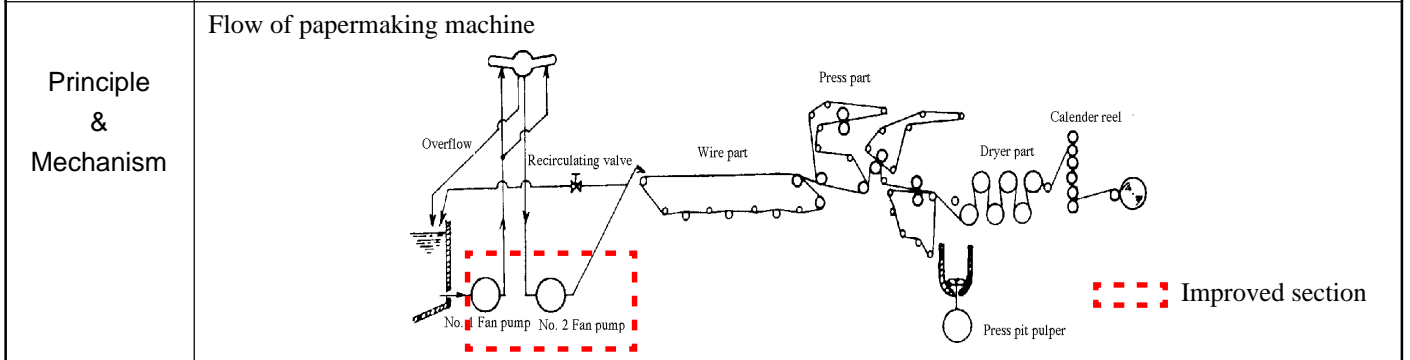
[Example sites]	[References] The Journal of Japan Technical Association of the Pulp and Paper Industry (Vol.51, No.1, 1997, P. 73; Vol.51, No.11, 1997, P. 90)	[Inquiry] Japan Paper Association / ECCJ (JIEC)
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PP-ME-15

Energy Conservation Directory

[Industry Classification] Paper & Pulp	Rotation control of equipment in the papermaking process	[Energy Source] Electricity
[Technology Classification] Machinery & Equipment		[Practical Use] 1980

Outline The pulp and paper mills operate a large number rotating machines; pumps, blowers and others. The papermaking machine, in particular, continuously operates large machines. The present case incorporated rotation control in the newly installed papermaking machine and thus promoted energy saving.



[Description] Structure explanation, Shape, and/or System diagram

1) Press pit pulper
The press pit pulper requires a processing capacity of 360 tons per day when the papermaking machine run out of paper; however, under normal conditions, it operates at a rate of 30 tons per day. The rotation is reduced to 40 percent of the capacity to reduce energy consumption under normal operating conditions, with a provision to automatically increase the rotation to 100 percent in case of papermaking machine running out of paper. Thus, energy consumption is reduced under normal operating conditions.

Specifications of the facilities
 Motor with eddy-current coupling: 215 kW, 1480 rpm
 Output in case of papermaking machine running out of paper: 156 kW, 1440 rpm
 Output under normal conditions: 72 kW, 1,000 rpm
 Operation hours a year: 8,000 (with high speed operation 200 hours)
 Energy saving: $(156 - 72) \times (8,000 - 200) = 655,000 \text{ kWh}$

2) Nos. 1 and 2 fan pumps and the high-pressure washing pump

Table 1 Modifications of the pump and fans

	Before modification	After modification
Nos. 1 and 2 fan pumps	These pumps fed the raw material to the papermaking machine, with the flow rate controlled according to the thickness of the paper to be produced. The pumps rotated at a high speed. The feed flow rate was controlled by overflow from the deregulator and control valves.	The rotation of the pumps is controlled to feed the raw material at the right flow rate.
High-pressure wash pump	The pump was run at a high speed. The pressure was controlled by control valves	The rotation of the pump is controlled to deliver the right volume.

Energy saving effects

Table 2 Energy saving and environmental conservation effect

	Capacity	Reduction of electric power consumption	Results
Press pit pulper	215 kW	655,000 kWh/y	Total 2,071,412 kWh/y
Nos. 1 and 2 fan pumps	770 kW	1,360,000 kWh/y	
High-pressure wash pump	150 kW	56,412 kWh/y	
Energy saving -crude oil equivalent			503 kL/y

[Economics] Equipment cost
 Investment amount (A): 25 million yen
 Improvement effect (B): 25 million yen/year
 Investment payback (A/B): 1 year

Remarks

[Example sites]	[References] “Collection of improvement cases at excellent energy management plants (1981)”, National committee for the effective use of electricity	[Inquiry] Japan Paper Association / ECCJ (JIEC)
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PP-OM-1

Energy Conservation Directory

[Industry Classification] Paper & Pulp	Improvement of dryer part hood to closed type to raise exhaust gas temperature to prevent dew condensation	[Energy Source] Fuel (steam)
[Technology Classification] Operation & Management		[Practical Use] 1970

Outline
The dryer part of the paper-making machine consists of a number of cylinder dryers. The exhaust is forced out by the induced draft fan. Traditionally, the dryer part was either semi-closed or open. In the present improvement, the dryer part was closed to recover waste heat contained in the large amount of exhaust. Heat loss from the dryer part was prevented, thereby the temperature of the paper surface and the exhaust was raised. Also the flows of feed air and exhaust were improved. This prevents moisture from condensing to form dews on the dryer part. Further, heat from the exhaust is recovered and used for preheating the feed air to the dryer part and to heat water. This contributes to energy saving.

Principle & Mechanism
Raising the temperature inside the hood to prevent dew condensation leads to a great reduction of steam consumption. The new hood has better heat insulation and improves the flows of air inside the hood. As the openings are sealed, the inside temperature is raised to a maximum of 65°C.

[Description]
1) The dryer hood is improved to a fully closed type.
2) The exhaust temperature is increased, and its dew point is raised to 61-65°C.
3) As the exhaust temperature is increased, a waste heat recovery system is installed. Waste heat is effectively used for heating feed air, or recovered as hot water. (Refer to Fig. 1)
4) As a result, power for the feed air and exhaust fans is reduced. Steam consumption for drying is reduced as well.

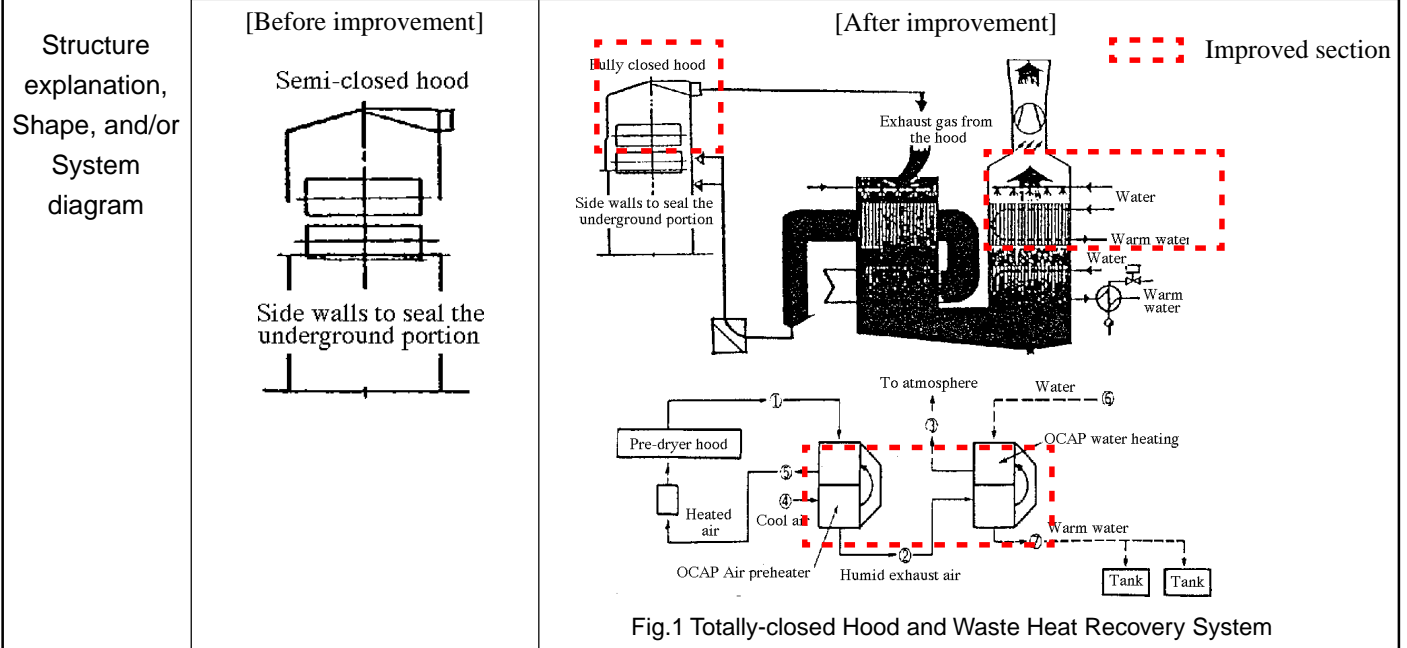


Table 1 Energy saving effect of improvement

Energy saving effects	Conditions after modification	After modification
Reduction of steam consumption, %	Increase of dew point from 58° C to 66° C (8° C up)	5
Reduction of electric power consumption of the supply and exhaust fans, %		40
Improvement of productivity, %		5

[Economics]
Investment amount (A): 220 to 350
Improvement effect (B): 27 million yen/year
Investment payback (A/B): 5 years
Cost of the equipment : About 350 million yen for 167 t/D per production

Remarks

[Example sites]	[References] “Pulp and paper Technology Times” (Vol. 31, No. 4, 1988, P.19;)	[Inquiry] Japan Paper Association / ECCJ (JIEC)
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PP-OM-2

Energy Conservation Directory

[Industry Classification] Paper & Pulp	Energy saving of vacuum pump for paper-making machine	[Energy Source] Electricity
[Technology Classification] Operation & Management		[Practical Use] 1992

Outline
In the drying process in paper making, it helps to save energy to suck the moisture content out from wet paper web as much as possible by a vacuum pump before steam drying. This sucking operation directly affects the quality of paper; therefore, energy saving in this operation has lagged behind. Traditionally, the vacuum pump was operated under the same condition without regard to the paper type and its moisture content. By controlling the rotation of the vacuum pump, the specific electric power consumption is greatly reduced.

Description of Process
[Vacuum pump]
- Number of units: 17
- Electric capacity: 533.5 kW in total

[Description of Improvement]

[Before modification]

- 1) The vacuum pump was operated without regard to the thickness of the paper to be produced, cleanliness of the papermaking machine parts, production rate, or operating condition.
- 2) Since the vacuum pump has excess capacity, the vacuum pump was operated with the vacuum breaker valve open, inducing the air. Thus, excess electric power was unnecessarily consumed.

Structure explanation, Shape, and/or System diagram

Fig. 1 Flow before improvement

[After modification]

- 1) An inverter control is applied to the motor for driving the vacuum pump to control the rotation. By controlling the rotation, degree of vacuum is adjusted as necessary with the throttling valve of the vacuum breaker half open to almost closed. This way, annual electric power consumption has been reduced.
- 2) Remote control of the dehydration of the wet web has been made possible by adjustment of rotation by inverter control. This improved the operability of the system.

Fig. 2 Flow after improvement

Energy saving effects

	Before improvement	After improvement	Effect
Specific electric consumption	454.2 kWh/t	406.8 kWh/t	47.4 kWh/t (10% reduction)
Electric consumption	3,779,800 kWh/y	1,711,400 kWh/y	2,068,400 kWh/y (reduction)
Crude oil equivalent			503 kL/y (reduction)

[Economics] Equipment cost
Investment amount (A): 21.4 million yen
Improvement effect (B): 21.6 million yen/year
Investment payback (A/B): About 1 year

[Remarks]
Materials of key parts are titanium, hastelloy C and ceramics.

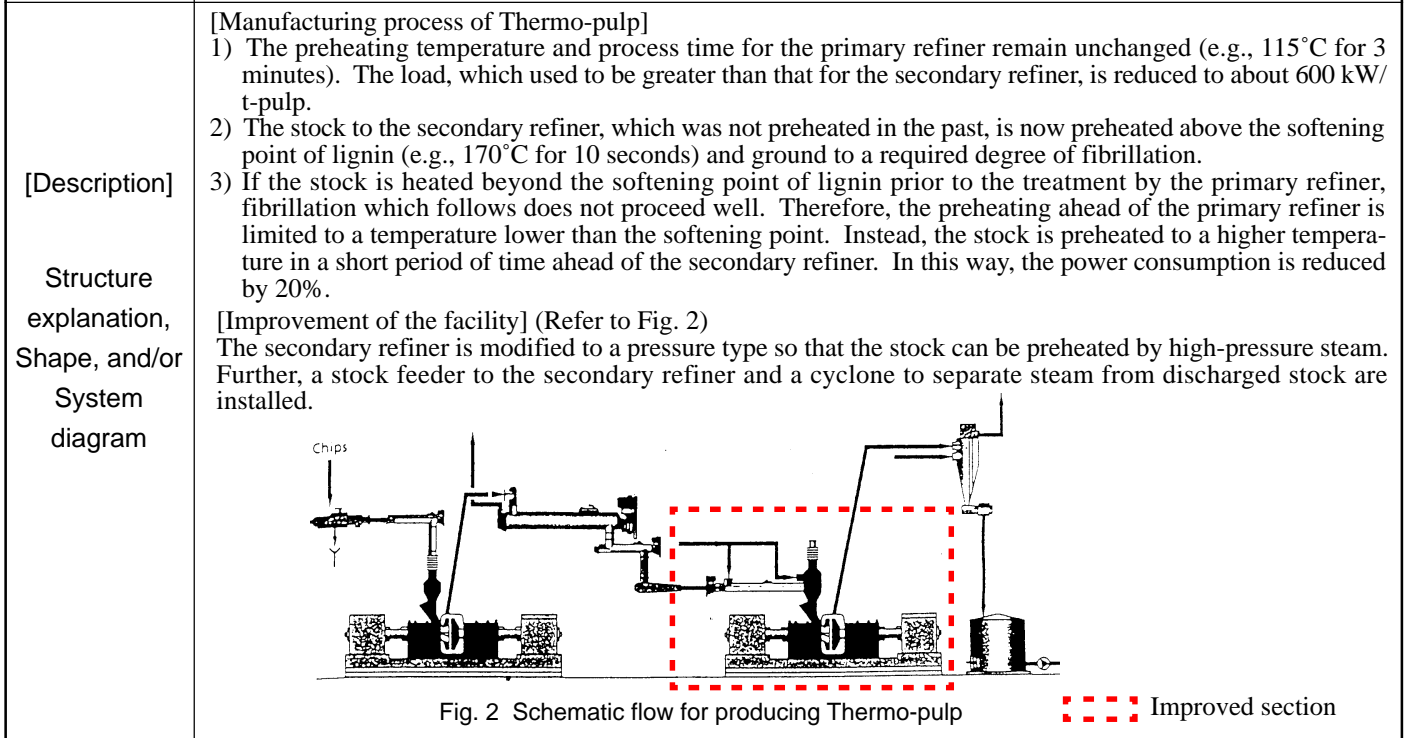
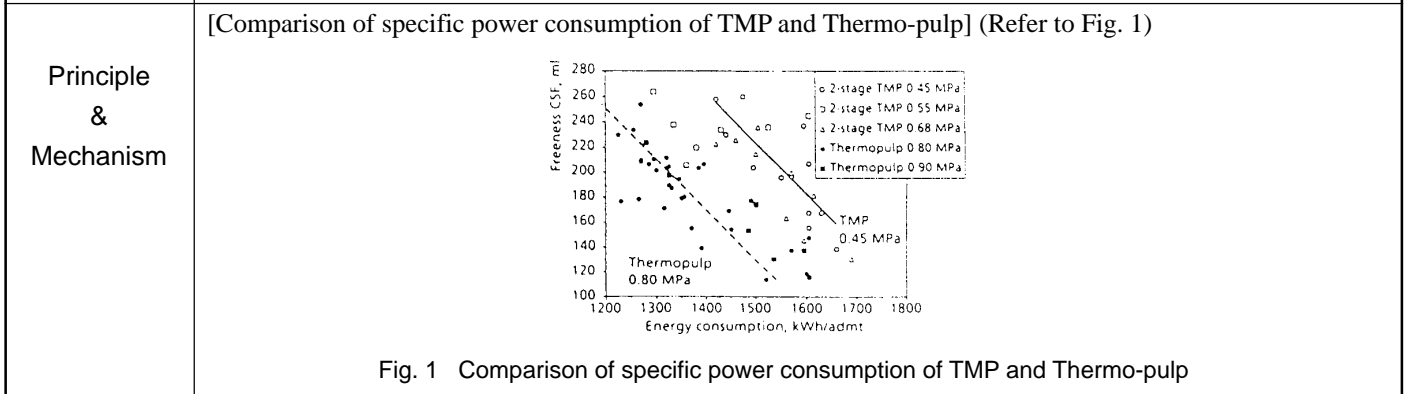
[Example sites]	[References] “Collection of improvement cases at excellent energy management plants (1995)”, National committee for the effective use of electricity	[Inquiry] Japan Paper Association / ECCJ (JIEC)
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PP-OM-3

Energy Conservation Directory

[Industry Classification] Paper & Pulp	Energy efficient production process of thermo-mechanical pulp (TMP)	[Energy Source] Electricity
[Technology Classification] Operation & Management		[Practical Use] 1995

Outline
Thermo-mechanical pulp (TMP) is the most important raw material for newsprint paper because it has high quality and high production yield compared with other types of mechanical pulp. Its drawback is that it has the highest specific power consumption among all types of high-yield mechanical pulp. As a countermeasure, a new process was developed, which can produce TPM with less power without sacrificing the quality, and was commercialized under the trade name of Thermo-pulp.



Energy saving effects

Specific power consumption	Reduction of 15 to 25% depending on wood types
Productivity improvement	Production increase of about 50 t/d per line

[Economics] Equipment cost
Specifications of the equipment: pulp production 300 t/d, refiner 16,000 kW x 1 unit, modified to a high-pressure type, preheater by high-pressure steam, stock feed conveyor, steam-separation cyclone 1 unit.
Cost of the equipment: 250 million yen for the equipment and 150 million yen for engineering and construction. 400 million yen in total.
Improvement effect: 236 million yen/year Investment payback : 1.7 years

Remarks	[Example sites] Started to be adopted.	[References] Makers' catalogs and technical documents	[Inquiry] Japan Paper Association / ECCJ (JIEC)
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