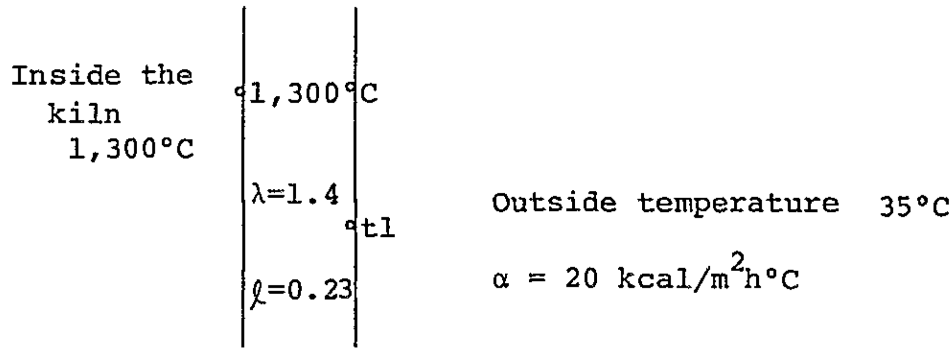
thick) at the burner part, heat release from this part was estimated under the following conditions.



$$Q = 5{,}900 \text{ kcal/m}^2\text{h}$$

$$tl = 330°C$$

The area of the burner part is:

$0.9 \text{ m} \times 0.9 \text{ m} \times 8 \times 2 = 13 \text{ m}^2$

Then, heat release from the burner part amounts to:

$5{,}900 \text{ kcal/m}^2\text{h} \times 13 \text{ m}^2 \times 24 \text{ h/d} \times 360 \text{ d/y}$

$= 662{,}688{,}000 \text{ kcal/y}$

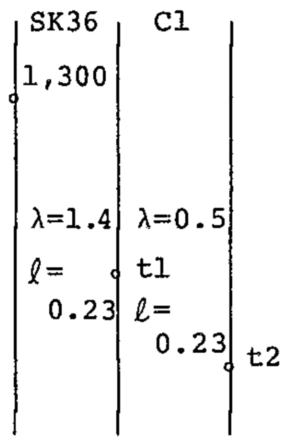
And heat release from all sides, other than the burner part, of the firing zone is calculated at:

$503 \text{ kcal/m}^2\text{h} \times 100 \text{ m}^2 \times 24 \text{ h/d} \times 360 \text{ d/y}$

$= 434{,}592{,}000 \text{ kcal/y}$

Heat release from the burner part is 1.5 times larger than from the other parts.

If one more refractory brick is given to the burner part from outside, then heat release can be prevented to a substantial degree as shown below, as far as the calculation goes.



Outside temperature 35°C

$\alpha = 15\ \text{kcal/m}^2\text{h°C}$

$Q = 1,830\ \text{kcal/m}^2\text{h}$

$t1 = 999°\text{C}$

$t2 = 157°\text{C}$

An annual saving of fuel that can be achieved by this insulation improvement will be:

$$(5,900 - 1,830)\ \text{kcal/m}^2\text{h} \times 13\ \text{m}^2 \times 4\ \text{kilns} \times 8,640\ \text{h/y} \times \frac{1}{9,500\ \text{kcal/liter}} = 192.5\ \text{kl/y}\ (\Delta 3\%)$$

Moneywise, this will amount to:

192.5 kl/y x 4,789 bahts/kl = 922,000 bahts/y

The cost of improvement work, meanwhile, can be estimated at 2,000 bahts/m^2, so the total cost will be:

2,000 x 13 x 4 = 104,000 bahts

This cost can be recovered within a very short period of time; it is advised to carry out improvement work on the first opportunity after consultation with a competent engineering firm, because it is rather difficult to contract work of this scale.

(3) Insulation improvement on carriages

Since energy required for heating a carriage accounts for a greater proportion of the whole, it is effective to insulate its upper part. This can be done by, for example, using less firebricks and more light refractory bricks, or coating the carriage with ceramic fibers.

To give an example in Japan, a saving of 5 to 8 percent of energy was achieved by coating the carriage with 25 - 30 mm thick ceramic fibers.

Moreover, better insulation of the carriage has some additional effects such as the improvement of production capacity due to higher kiln temperatures, and the increased cooling speed in the cooling zone.

(4) Waste heat recovery

A. Preheating of primary air for combustion (in Nos. 2 - 4 kilns)

The air from the cooling zone is normally used for drying and other purposes, but if it is used directly as the primary air for combustion, then much fuel can be saved.

Waste heat for drying will rarely be in short supply. If in short, fuel in an amount matching the operation of the spray dryer can be more economically used as a whole.

10 to 30 percent of the air for combustion is used as the primary air. Supposing that 20 percent of the air for combustion is used as the

primary air, preheated by the heat left in the cooling zone, and collected at 400°C and beyond on a cooling curve, let us work out how much fuel can be saved.

Given data are:

Consumption of fuel oil - 180 liters/h kiln

Theoretical amount of air -

$$Ao = \frac{0.85\ Hl}{1,000} + 2.0 = 10.0\ Nm^3/kg$$

Air ratio -

$$m = 1.2$$

With these data, the amount of the primary air (20%) is:

$$10.0\ Nm^3/kg \times 1.2 \times 180\ liters/h \times 0.953 \times 0.2$$
$$= 412\ Nm^3/h$$

If the air with the temperature of 200°C can be obtained, then;

$$0.31\ kcal/Nm^3{}^\circ C \times 412\ Nm^3/h \times (200 - 30)^\circ C$$
$$= 21,712\ kcal/h$$

$$21,712\ kcal/h \div 9,500\ kcal/liter = 2.3\ liters/h$$

Given the fuel consumption 180 liters/h, a fuel saving that can be achieved is:

$$2.3\ liters/h \div 180\ liters/h \times 100 = 1.3\%$$

B. Preheating of air for combustion (No. 1 kiln)

Since the No. 1 kiln is fitted with proportional regulating burners, preheating will produce effectes to the whole amount of air. A saving of fuel that can be achieved by preheating is calculated at:

$0.31 \text{ kcal/Nm}^3 °C \times 10.0 \text{ Nm}^3\text{/kg} \times 1.2 \times$

$180 \text{ liters/h} \times 0.953 \times (200 - 30)°C$

$= 108{,}482 \text{ kcal/h}$

In terms of fuel, this amounts to:

$108{,}482 \text{ kcal/h} \div 9{,}500 \text{ kcal/liter} = 11.4 \text{ liters/h}$

Taken together, a saving of fuel for the four kilns is:

$2.3 \text{ liters/h} \times 3 + 11.4 \text{ liters/h} = 18.3 \text{ liters/h}$

(160 kl/y)

The air now can be preheated to the level of about 600°C. It is advised to carry out this measure after confirmation to the manufacturer of the heat proof of burners.

C. Use of kiln ceiling heat for preheating of fuel oil

At the No. 1 kiln, heat given off by its ceiling was used for preheating fuel oil, which is really worth noticing.

At most of the Japanese factories, water is heated on top of a kiln so that heated water can be used to heat fuel oil from consideration of fire.

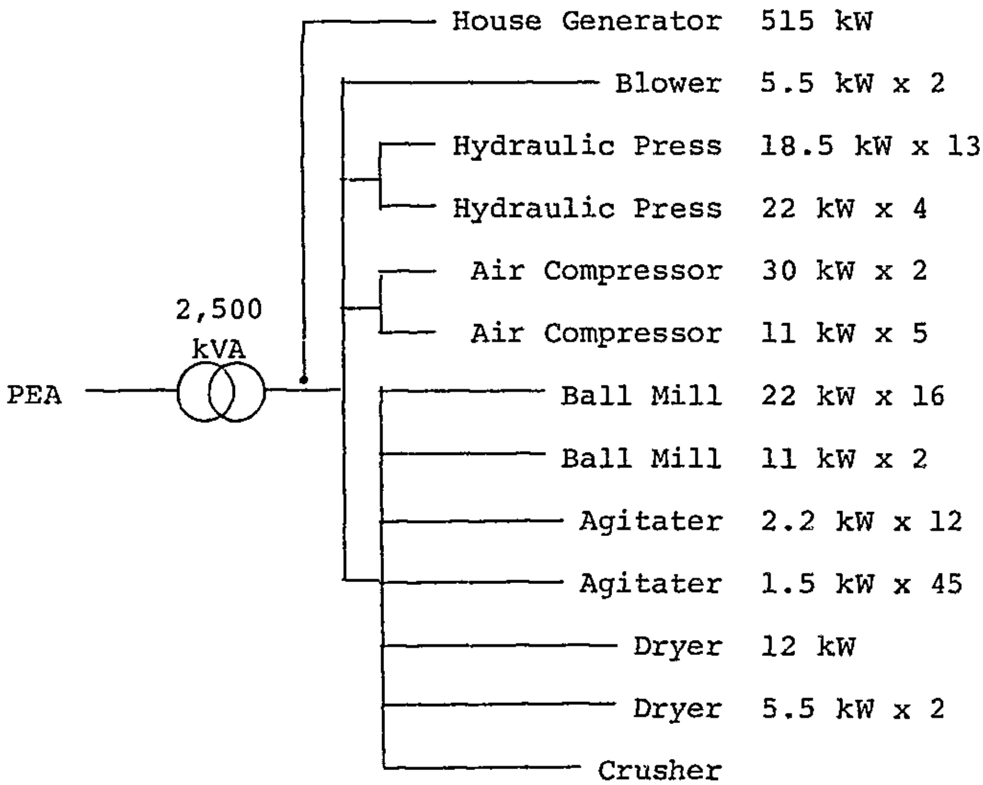
7. State of Electric Power Consumption

(1) The principal data relating to power consumption are as follows:

Power company - PEA

Peak demand	-	1,245 kW
Electric power used	-	558,420 kWh/m
Load factor	-	62.2%
Penalty	-	No penalty
Power factor	-	93% (measured value)
Transformers	-	2,500 kVA, and 22 kV/400 V

(2) One-line diagram



Being large in scale, this factory is well-furnished and active in improving the power factor. Although the consumption of electric power was recorded every hour, a daily load curve was not used effectively.

8. Problems in Electric Power Control and Potential Solutions

(1) Transformers

Shown below are data on the voltage at the switches of major equipment. The voltage stood at a rather high level of 391 to 398 V, regardless of the distance from transformers as well as the installation of condensers.

Operation of Major Loads

Equipment A	Distance from transformer	Voltage (V)	Electric power (kW) B	Power factor (%) with condenser	Power factor (%) without condenser	$\frac{B}{A}$ %
Compressor 30 HP (22 kW)	Far (70 m approx.)	393	15	87	73	68
	Medium	398	17	98	79	77
	Near	398	18	100	82	82
Hydraulic press 30 HP (22 kW)	Far (50 m approx.)	393	21 - 48	94	-	95
	Medium (25 m approx.)	397	15	-	64	68
Compressor 40 HP (30 kW)	Far (30 m approx.)	392	29		89	95
	Near (25 m approx.)	391	28		92	93

Speaking of motors, if the supply voltage is high, then the power factor will drop. So taps on the transformer should be re-connected so that the supply voltage is brought down to 380 V or a little lower. Then, the power factor for motors will be imporved by 2 to 3 percent and the core loss of the transformer will decrease in proportion to the square of the voltage. Supposing that the core loss of the 2,500 kVA transformer is 1.3 percent, a reduction in this core loss will amount to:

$$2,500 \times 0.013 \times 0.2 \times \left\{ \left(\frac{400}{390}\right)^2 - 1 \right\} \times 8,760$$
$$= 3,000 \text{ kWh/y}$$

(2) Daily load

Based on data on daily load, the consumption of electric power reaches its peak once a day at around 9 to 10 a.m., then gradually goes down, and decreases to a marked degree after 11 a.m. The peak of the electric power consumption follows again in the afternoon and later on the day for a short time.

To hold down the peak demand at 9 to 10 a.m., therefore, it is desirable to provide a little time lag in starting equipments, rather than setting all equipments in motion simultaneously upon commencement of work. Controlling the operation of ball mills, among others, will be highly effective.

If the peak demand is reduced by about 7 percent, then a saving on electricity bills will amount to:

1,245 kW x 0.07 x 88 bahts/kW x 12 m/y

= 92,000 bahts/y

(3) Power factor

With condensers of 300 kVr (10 kVr x 30) installed, the power factor for the factory runs at 94 percent.

Each one of the 30 HP motors for ball mills is, however, fitted with a 10 kVr condenser designed to improve the power factor. As a consequence, though wiring loss was made smaller, some of the ball mills installed near the transformer were found to have the power factor of over 100 percent.

A solution to this problem is to remove condensers form those 4-ton ball mills (about five of them installed near the transformer) whose power factor stands at 95 percent or higher and put them collectively into the electric circuit (power receiving room) for small motors. This is because condensers can be more effectively utilized if fitted into small motors that are intensively and continuously run.

9. Summary

The above remedial measures, if actually taken, are expected to bring about energy-saving effects as shown below:

Measures	Potential energy saving	Rate (%)
Prevention of air escape by putting carriages in good	fuel oil 508 kl/y	8

condition,

Insulation improvement on burner part	fuel oil	192 kl/y	3
Insulation of upper part of carriage	fuel oil	500 kl/y	8
Preheating of air for combustion	fuel oil	160 kl/y	2
Subtotal		1,360 kl/y	21
Lowering of voltage through reconnection of transformer tap	electricity	3,000 kWh/y	-

Report No. 6: Ceramics

REPORT ON THE DIAGNOSIS

FOR

ENERGY CONSERVATION

- Thailand Tile and Pottery Co., Ltd. -

January, 1983

Japan International Cooperation Agency

Contents

The Diagnosis for Energy Conservation

- Thailand Tile and Pottery Co., Ltd. -

1. Outline of the Factory

Address : 131 Shertakish 1 Rd., Omnoi, Amphor Kratumbaen, Samutrsakorn

Capital : 10 million bahts

Type of industry : Ceramics

Major products : Mosaic tiles and quarry tiles

Annual output : 2,400 t

No. of employees : 85

Annual energy consumption :

- Electric power : 639,020 kWh
- Fuel
  - Fuel oil : 1,152 kl

Interviewee : Prakob Liupolvanish, assistant manager

Date of diagnosis : Sept. 9 - 10, 1982

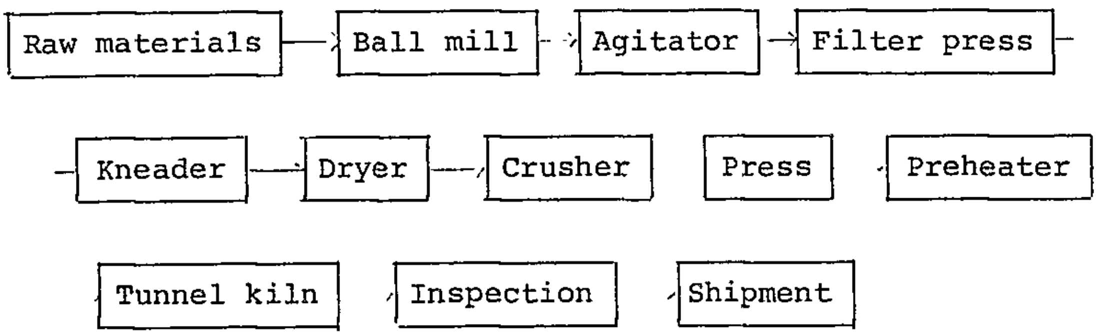
Diagnosers : M. Ito, Y. Ohno, and T. Sugimoto

Thailand Tile and Pottery's factory has a production capacity of 10 tons a day. Currently, it has an output of 7 tons a day, of which quarry tiles account for 60 percent and mosaic tiles 40 percent.

Since the ratio of fuel costs to sales runs at as much as 30 to 40 percent, the factory manager has a great interest in energy conservation; he goes round for site inspection frequently, he looked like studying the way of operational improvement on his own. He wanted to make improvements on the present kiln, which had been installed ten years ago.

The factory, though rather dusty, is found to be kept in relatively good order. Viewed from equipment management, good maintenance of carriages attracted our particular attention.

2. Manufacturing Process



3. Major Equipment

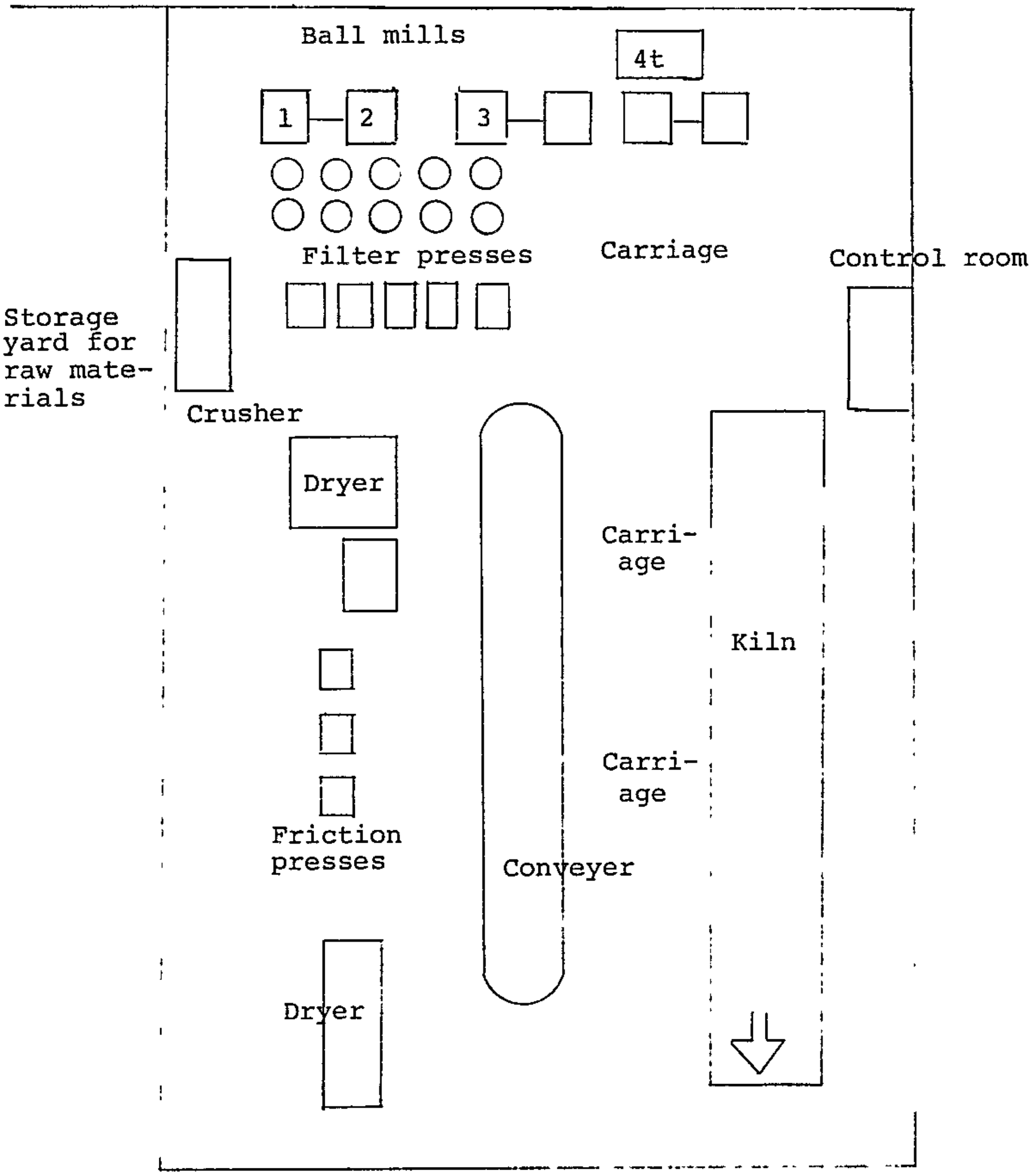
(1) Major equipment

Name	No. of units installed	Type, etc.
Ball mill	7	2-ton x 6, 4-ton at rest
Filter press	4	
Dryer	2	Using waste heat, drying chamber
Dryer	1	Net conveyer, using waste heat
Press	4	300-ton x 1, 100-

			ton x 3
Tunnel kiln		1	Side burners, made by Mino Ceramics Co., of Japan

	Preheating zone	Firing zone	Cooling zone	Total
Length	21,450	21,300	21,070	63,820
Width	3,400	3,900	2,300 ~ 2,760	
Height	2,650	2,650	2,650	

(2) Layout


Ball mills
4t
1
2
3
Filter presses
Carriage
Control room
Storage yard for raw materials
Crusher
Dryer
Carriage
Kiln
Carriage
Friction presses
Conveyer
Dryer

4. State of Energy Management

The factory manager has a deep interest in energy conservation, hoping to achieve a saving of about 10 percent of energy. Nevertheless, no specific target figures have been set and shown to workers.

The consumption of fuel is recorded in a daily report, but no attempt has so far been made to evaluate the consumption rate.

The promotion of energy conservation is not specifically organized but it is given attention by the personnel in charge of operation as part of their routine work.

Engineers are educated by technical experts from abroad; general workers are also given training so that, for example, they will not start motors all at once. There is no suggestion system of any sort adopted to encourage employees to put forward proposals for improvement, because, in the management's opinion, such proposals are difficult to evaluate whether they work or not.

Measurement is relatively frequently carried out; the kiln is fitted with a thermometer, pressure gauge, and fuel flow meter, whose readings are recorded in a daily report.

5. State of Fuel Consumption

Fuel is burnt in the tunnel kiln alone, and waste heat coming out of the kiln is used for drying.

Output - 2,400 t/y, 7 t/d

Fuel oil - 1,152 kl/y

(estimated heat contents:

9,500 kcal/liter)

Fuel consumption rate - 480 liters/t, 4,560,000 kcal/t

The thermal efficiency stands at 8.3 percent, which is the average value for outmoded tunnel kilns.

Supposing that the firing temperature is set at 1,250°C and the average specific heat at 0.31 kcal/kg°C, then the effective heat is

1,000 kgs/t x (1,250 - 30)°C x 0.31 kcal/kg°C

= 378,200 kcal/t

The input heat is:

480 liters/t x 9,500 kcal/liter

= 4,560,000 kcal/t

And the thermal efficiency is: 8.3 percent

6. Problems in Heat Control and Potential Solutions

(1) Combustion control

A. Of eight pairs of burners in the firing zone, three pairs on the preheating side are turned off, which can be looked upon as a sign of their energy-saving efforts.

B. As mentioned earlier, carriages are all kept in good order; no skirts for the carriages are warped and sanded iron plates are glistening evenly. According to the results of a gas analysis, no air is found to have been escaping from under the carriage into the kiln.

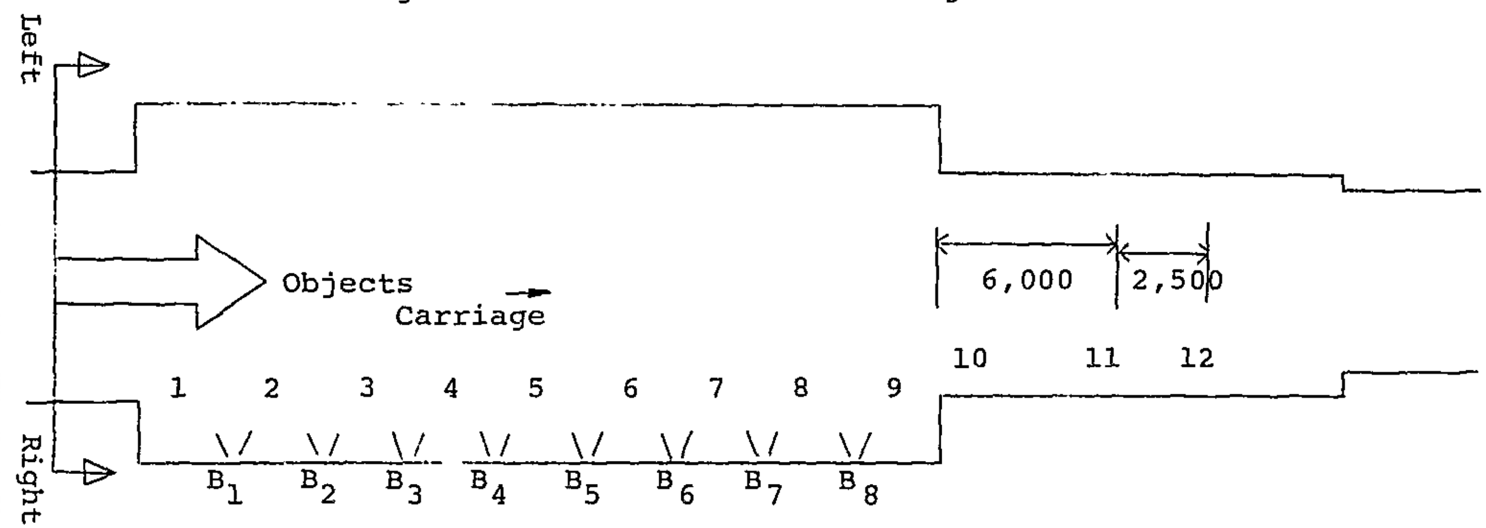
C. Shown in Fig. 1 are the results of an analysis of the air ratio. The air was in slightly short supply, though it may be that the results were rather small figures due to the sampling tube made of common steel. Still, it is necessary to regulate the kiln pressure level as well as the amount of fuel and air for burners.

D. Burners were not atomizing fuel adequately, giving off sparks. This seems to be because nozzles are stained; burners are installed in a wrong direction; there is a shortage of atomizing air; and the amount of fuel oil is throttled too much.
The current consumption of fuel should be checked against specifications for burners.

E. To prevent the kiln gas flow from being disturbed, it is necessary to leave the door open in as short a time as possible. Recommended measures are to provide an air curtain or to fit a double door.

F. The temperature of returned oil is found to be at an excessively low level of 40°C. The thermometer should be checked to see if it is properly fitted. And if there is actually such a drop in the temperature of oil, it is necessary to provide heat insulation.

Fig. 1 Combustion in the Firing Zone



Measured points		1	2	3	4	5	6	7	8	9	10	11	12
Oxygen content	Upper					0.2	1.1	0.3		7.5 / 9.0	20.3		
	Middle					2.1	0.9	0.2	0.1	3.0 / 0.6			
	Lower					2.9	1.5	0.2	0.1	18.6 / 18.7	20.8		
Kiln pressure	Upper	-1.1 / -1.0			-0.7 / -1.2		+0.4			+0.6	+0.6	+0.2	+0.3
	Middle	-1.5 / -1.7			-1.1		-0.5			+0.1			
	Lower	-2.0 / -2.1			-1.9		-1.0			-0.3	-0.2	-0.5	X

(2) Heat release from the kiln body

The measured values of surface temperatures and heat flux in the firing zone are given in Fig. 2.

Average surface temperature - 129°C

Heat flux - 1,447 kcal/m^2h

The total area of this zone including its both side walls and ceiling is 122.5 m^2, so heat release will amount to:

1,447 x 122.5 = 177,300 kcal/h

The common practice among many Japanese factories is to spray the surface of a kiln body with rock wool for better insulation.

If the kiln body is sprayed with rock wool to a thickness of 25 mm, then the surface temperature will drop to 107°C and heat release will be lowered to 991 kcal/m^2h.

Also, fuel can be saved by the following amount:

$$(1,447 - 991)\text{kcal/m}^2\text{h} \times 122.5\ \text{m}^2 \times \frac{1}{9,500\ \text{kcal/liter}}$$

$$= 5.9\ \text{liter/h}$$

All in all, an energy saving of 4.5 percent can be achieved. Insulation improvement on the preheating zone, in addtion to the firing zone, could bring about additional energy saving of more than 5 percent.

The cost of improvement is estimated at 2,000 bahts per square meter. If the whole area of 383 square meters - both the preheating and firing zones - is given better insulation, therefore, the total cost will amount to:

$$2{,}000 \text{ bahts/m}^2 \times 383 \text{ m}^2 = 766{,}000 \text{ bahts}$$

This cost can be recovered within 2.8 years, because a saving of 5 percent in fuel is equivalent to a reduction in operation costs amounting to:

$$1{,}152 \text{ kl/y} \times 0.05 \times 4.75 \text{ bahts/liter}$$

$$= 274{,}000 \text{ bahts/y}$$

Note should be taken of the fact, however, that improved insulation on the surface of the kiln wall will raise the temperature at its middle section. So bricks lining the kiln should be examined to see if they stand higher temperatures.

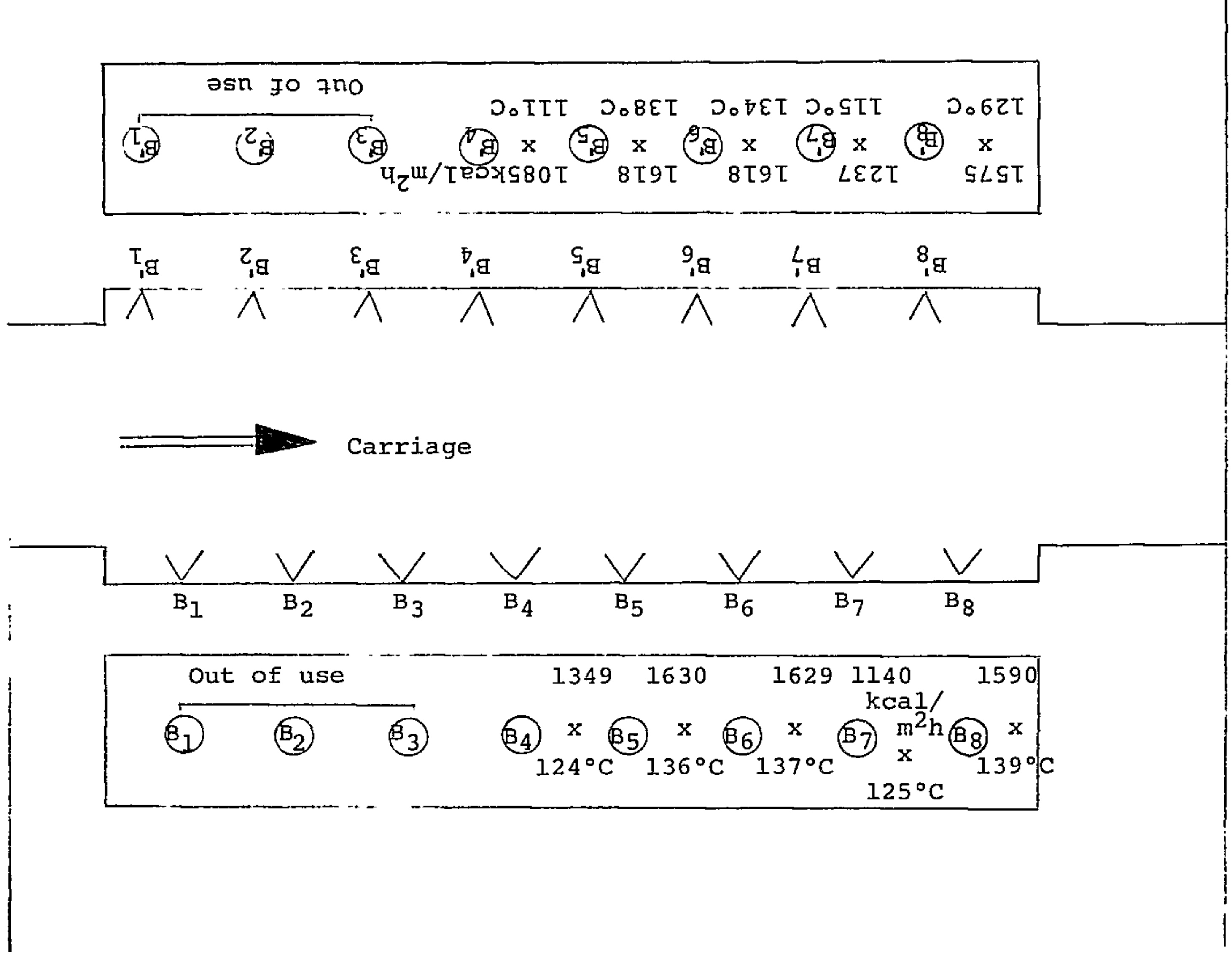
(3) Improvement of the way to load the kiln

A gap between the kiln wall and things to be heated should be narrowed as much as possible so that gas can be prevented from by-passing. To do so, it is a common practice to provide a gauge having the same shape as the section of an inner shell and use this gauge for checkup when the kiln is loaded with carriages. Simple as it can be, this practice should preferably be followed.

(4) Insulation improvement on the upper part of carriage

It is a markedly effective measure to use less firebricks and more light refractory bricks at the top of a carriage or line it with ceramic fibers. Put a carriage lined with ceramic fibers into a kiln, by way of experiment, and you will see how dramatic

Fig. 2 Surface Temperatures and Heat Flux in the Firing Zone



effects can be achieved. A saving of about 8 percent of energy, for instance, has been achieved by lining carriages with 50 mm-thick ceramic fibers here in Japan.

(5) Making saggers lighter in weight

Tiles placed on each carriage weigh about 350 kgs, whereas saggers weigh as much as 1,400 kgs or approx. four times heavier. This means that a larger amount of heat is required. It is necessary, therefore, to make saggers lighter in weight and to lessen the inner space of a sagger by stuffing it with as many products as possible.

(6) Use of waste heat

The hot air from the cooling zone seems to have been in excess. Using a part of it to preheat the air for combustion will have considerable effects on energy conservation.

Based on the flow rate measured at the suction, the amount of primary air fed by the blower is calculated at:

$$1,600\ Nm^3/h$$

Supposing that this primary air is preheated through use of waste heat to reach a temperature of 200°C, then heat can be saved by the following amount:

$$1,600 \times (200 - 30) \times 0.31 = 84,320\ kcal/h$$

In terms of fuel oil, this amount is equivalent to:

$$\frac{84,320}{9,500} = 9 \text{ liters/h}$$

Thus, a saving of fuel that can be achieved by use of waste heat accounts for 7 percent of the total consumption of fuel.

It is desirable to make use of waste heat step by step while paying attention to the heat proof of the blower and burners.

In this connection, if the primary air is preheated up to a temperature of 200°C, then the amount of air passing through the blower will be:

$$1,600 \times (1 - 0.07) \times \frac{273 + 200}{273} \times \frac{1}{60}$$
$$= 43 \text{ Nm}^3\text{/min.}$$

This amount of air comes within the limits of the blower's capacity (45 m^3/min).

(7) Poor airtightness of the drying chamber

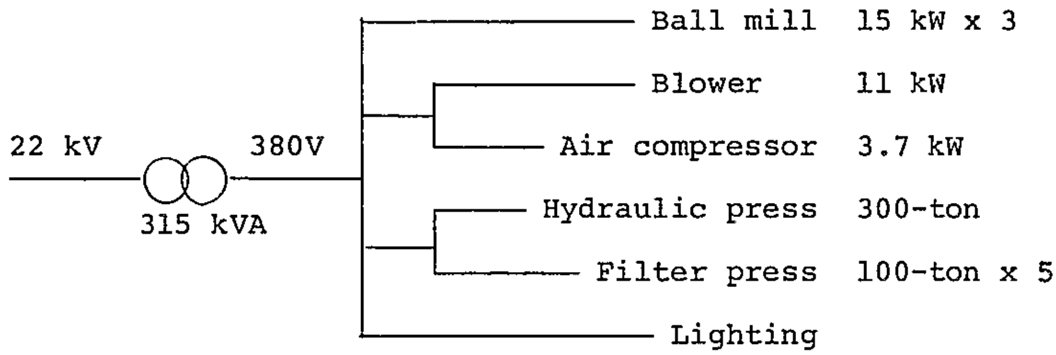
The drying chamber door was not in good order, so that waste heat was not utilized to the full and the distribution of inside temperatures was uneven. It is of vital importance to put the door in proper repair and let a hot air emit through several openings evenly so that irregularity in drying can be abated as much as possible.

7. State of Electric Power Consumption

(1) The principal data relating to power consumption are as follows:

Power company	-	PEA
Peak demand	-	148 kW
Electric power used	-	639,020 kWh/y
Load factor	-	50.7%
Penalty	-	No penalty
Power factor	-	64.5% (measured value)
Transformer	-	315 kVA

(2) One-line diagram



8. Problems in Electric Power Control and Potential Solutions

(1) Transformer

The secondary voltage of the transformer is found to have been rather high at 400 V. It is desirable to change a tap on the transformer so that the secondary voltage can be lowered to around 390 V (380 V or lower at the terminals of electric equipment). Then, the core loss of the transformer will be reduced and the power factor for motors, among others, will be improved, if only a little.

When it comes to the power factor, it is found to have been low at 64.5 percent. The overall power factor could be raised to about 92 percent by installing a condenser (80 kVA) at the transformer.

A possible reduction in the transformer loss can be realized by these remedies. It is estimated at:

$$315 \text{ kVA} \times (1 - 0.979) \times 0.8 \times \left\{ \left(\frac{233 \text{ A}}{466 \text{ A}}\right)^2 - \left(\frac{168 \text{ A}}{466 \text{ A}}\right)^2 \right\}$$

$$\times 8{,}640 \text{ h/y} = 5{,}500 \text{ kWh/y}$$

Where,

Rated current of transformer: 466 A

Current at power factor of 65%: 233 A

Current at power factor of 92%: 168 A

(2) Miscellaneous

Illumination is found to have been rather poor at the place where products are inspected (50 lux). Additional fluorescent lamps (40 W x 2) should be installed to provide better illumination and increase the efficiency of inspection work.

9. Summary

The aforementioned remedial measures, if actually taken, could bring about energy-saving effects as shown below:

Measures	Potential energy saving	Rate (%)
Insulation improvement on the kiln body	58 kl/y	5

Insulation improvement on the upper part of carriage	92 kl/y	8
Use of waste heat for preheating combustion air	80 kl/y	7
Total	230 kl/y	20
Resulting improvement of power factor	5,500 kWh/y	0.9

Report No. 7: Ceramics

REPORT ON THE DIAGNOSIS
FOR
ENERGY CONSERVATION

\- Super Fibre Cement Co., Ltd. -

January, 1983

Japan International Cooperation Agency

Contents

The Diagnosis for Energy Conservation

- Super Fibre Cement Co., Ltd. -

1. Outline of the Factory

Address : 88 SOI S. Thaisare 2, Suksawad Rd., Samutprakarn

Capital : 30 million bahts

Type of industry : Ceramics

Major products : Asbestos fibre cement sheet

Annual output : 47,500 t

No. of employees : 491

Annual energy consumption :

- Electric power : 2,506,250 kWh
- Fuel
  - Diesel oil : 473 kl

Interviewee : Smooth Poothavorn, factory manager

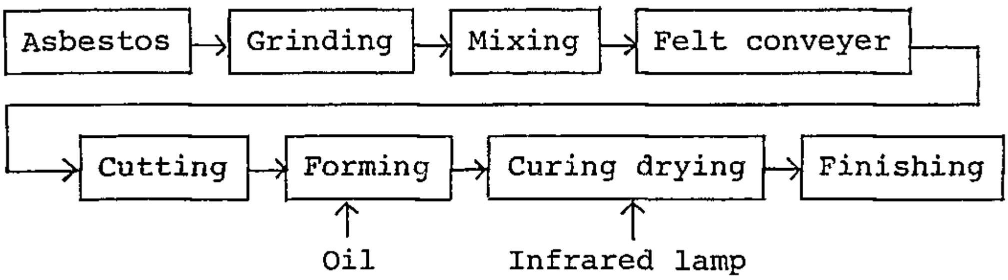
Date of diagnosis : Aug. 23 - 24, 1982

Diagnosers : M. Ito, Y. Ohno, and T. Sugimoto

Produces slate sheets for construction purposes (both corrugated and flat sheets) at a rate of approximately 4,000 tons per month, making the company about 4th among the nations' such 7 producers. The company had previously used steam to cure its products, but six months ago it switched to infrared lamps to heat up the product. The company uses about 473 kl of oil per year, but since it is used as a parting agent, there is no way to reduce fuel consumption.

Problems which the factory manager seems most concerned with are (1) the yield, that is, 4 - 5% of defective products that occur at shipping time due to cracks, etc., and (2) the relatively short lifespan of the infrared lamps now being used.

2. Manufacturing Process

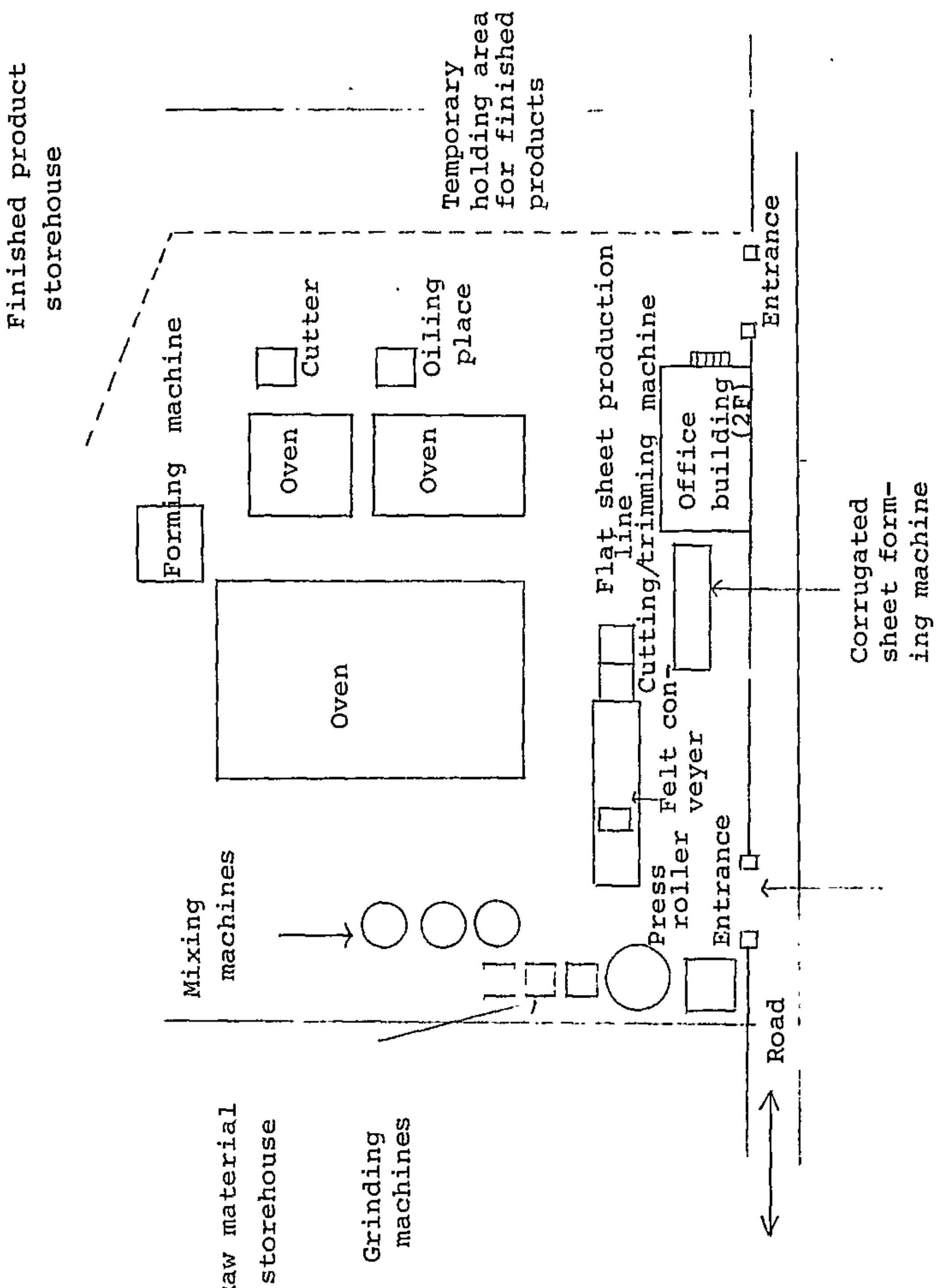


3. Major Equipment

(1) Major equipment

Name	No. of units installed	Type, etc.
Forming machine	3	37 kW; machine No. 2 not in use
Dryer	3	60 kW for flat sheets; 40 kW for corrugated ones

(2) Layout



Finished product storehouse
Temporary holding area for finished products
Forming machine
Cutter
Oiling place
Oven
Oven
Oven
Flat sheet production line
Cutting/trimming machine
Office building (2F)
Entrance
Entrance
Corrugated sheet forming machine
Felt conveyer
Press roller
Entrance
Mixing machines
Road
Raw material storehouse
Grinding machines

4. State of Energy Management

Their collection and organization of various kinds of data is quite complete, and they were able to produce any information that was needed to answer our questions very quickly. Even in regards to defect rates and equipment failure rates, they keep daily records as to the source of the problems.

A monthly cost target is set, and the factory office is prepared to chart it out on a graph.

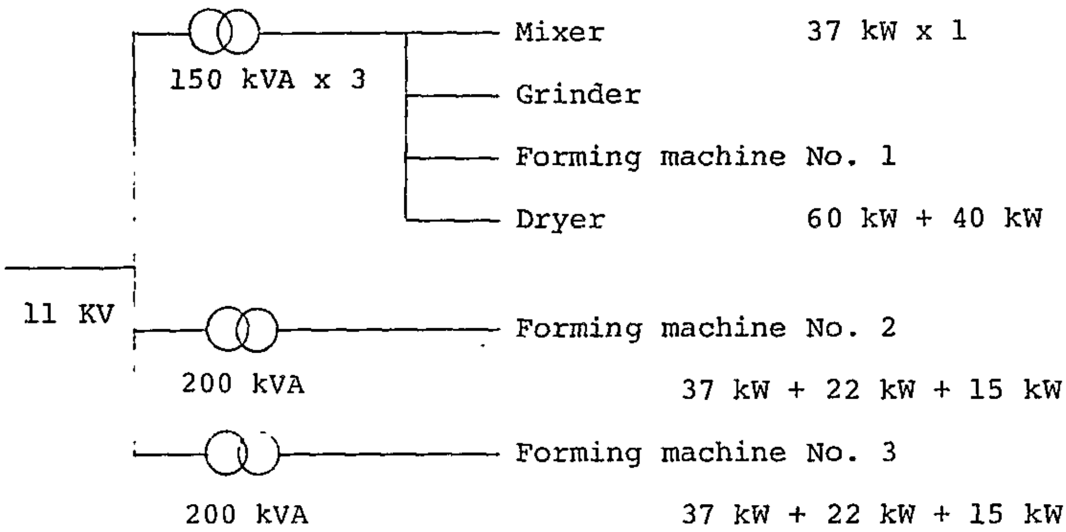
Regarding employee training, management says that its workers are not easy to train due to turnover proneness and almost none is currently being done. When there is a lot of personnel changing, in order to make the same products it is necessary to decide work standards, but this is not made. Perhaps for this reason, there are even some employees who are indifferent to product quality.

5. State of Energy Consumption

(1) The principal data relating to power consumption are as follows:

Power company	-	MEA
Peak demand	-	600 kW
Electric power used	-	266,000 kWh/m
Load factor	-	61.6%
Penalty fee	-	162 kVr
Power factor	-	75% (actual measurement 80%)

(2) One-line diagram



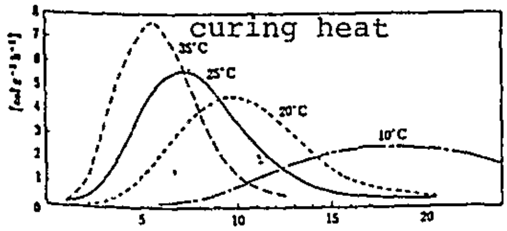
6. Problems in Energy Control and Potential Solutions

(1) Utilization of Reaction Heat

After the slate has been formed, it is put in between molds coated with diesel oil. This is loaded on a carriage and carried to the dryer to be heated and cured by infrared lamps for approx. 8 hours. Once out of the dryer, the mold is removed and it is further cured indoors in a natural way.

The figure below shows the relationship between the exothermic speed of hydration of heat and the curing temperature. As can be seen, the higher the temperature, the faster the reaction takes place. (Source: Chemical Handbook,Japan p.399)

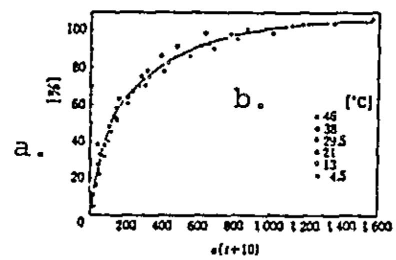
Exothermic Speed of Hydration vs. Curing Temperature



time (hours)

Moreover, finding the strength of the finished product is the result a(t+10) of the number of curing days (a) and temperature (t), as shown in the figure below. This means that the higher the temperature, the quicker the slate hardens. But if the temperature is too high the final strength of the product will be a bit lower than normal.

Relative Strength is the Result of Length of Time and Temperature



a. relative strength

b. curing heat

In this respect, raising the temperature during the curing process will speed up the reaction, but because cement will yield 125 calories/g of heat through hydration, it is better to make the most use of this reaction heat by insulation.

However, the dryer slate walls have holes in them, and the entrance doors are not covered down to the floor level, making the dryer not airtight and thus allowing heat to escape. It is desirous that the dryer be repaired to improve airtightness and that the employees be instructed to make sure that the curtain door is properly closed.

Measurements of Heat Distribution

a. Side temperature

No. of layers	After entering dryer				
	20 minutes	two hours		eight hours	
	long side	long side	short side	long side	short side
Upper level					
1	42°C	50°C	50°C	51°C	48°C
6	41	60	64	57	58
11	39	66	65	63	61
16	39	65	62	64	61
21	38	63	59	63	60
Lower level					
26	41	59	55	61	58

b. Upper surface temperature

Carriage No. 1

48°C		48°C
56	63	54
50		50

Carriage No. 2

48		48
54	62	55
48		48

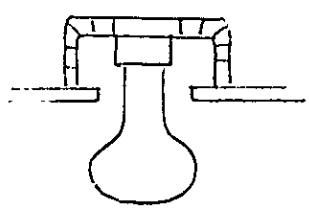
Carriage No. 3

45		46
58	62	54
51		47

Based on the above data of temperature measurements, it seems self heat generation probably more effectively raises the temperature of products than using infrared lamps heating. Accordingly, it is more effective to put the carriage into the dryer as many as possible to take advantage of reaction heating between the sheets. Moreover, it is also good to put a cover on the products. In this way once the temperature inside the dryer has gone up to a certain degree it would not matter even if the infrared lamps are put off.

(2) Life of the Infrared Lamps

One of the reasons for the relatively short service life of the infrared lamps is that the socket section is overheated. At this factory, measurements showed that socket temperature soared to 320 °C. It is therefore necessary to install the socket section outside the dryer in a manner that it can be air-cooled easily by the outside air. Moreover, the lamp of the unused dryer was left buring which also shortens lamp life.



(3) Reducing Use of Diesel Oil

When this diesel oil is put on the sheets as a parting agent, it is usually put on in excessive amounts and some of it falls on the floor. Therefore, it would save some now wasted oil if a pinch roll was used on the rear stage for example to avoid dropping excess on the ground.

(4) Crack Prevention

There is apparently a major difference in the strength of wet sheet between length and width. This seems to be because the liquid inside the feeder moves in the direction in which the roller is revolving and, therefore, the slate fibers in the liquid are all lined up in the same direction. Therefore, it is necessary to modify and improve the method of sending liquid to the feeder, so as to agitate the liquid in the feeder in width direction.

It seems that there is a desire to use cotton as fiber for their manufacturing process, however this requires the use of a beater to loosen the fibers. Regarding such beaters, there are some paper companies in Thailand (such as Cardboard Thailand or Industry Krung-Thai) which have idle beaters. How about making an inquiry to them?

Moreover, it was also noticed that on top of the wet sheets there are cutting scraps that have fallen from the cutter, and the position of the thickness gauge roller is bad, resulting in scratches on the finished products and causing other reasons for defected finished goods.

(5) Transformer Overload

The No. 1 transformer is operating at a 14% overload. The power factor is also bad (68%), therefore a 200 kVr condenser should be added or part of the load should be shifted to another transformer.

Benefits of Using 200 kVr Condenser

	Load	Power factor	Apparent power
Current setup	350+j373	68%	512 kVA(114%)
with 200 kVr condenser	350+j173	89%	390 kVA(87%)

By adding this condenser it will be possible to save an estimated 32,100 kWh/y [450 kVA x 0.016 x $\left\{(\frac{782}{643})^2 - (\frac{611}{684})^2\right\}$ x 8,760] as well as save the annual penalty fee of 29,000 bahts. Such a savings would enable the company to recover in a short period of time the estimated 50,000 bahts that would be required to install the condenser.

(6) Fall in Voltage

There is a 26 volts' fall between the No. 3 transformer and the 50 HP motor. The cause may be because the lines are too thin, or other causes. This matter should be investigated.

(7) Other Problems

Stagnant water was on the floor of the transformer room, and a danger of short circuit is worried of. More attention should be paid to drainage. Two of the five driving belts on the forming machine are torn, which is causing a loss of driving power. Also, the base of the machine is a little corroded which causes strong vibrations that can cause breakdowns.

7. Summary

We conclude that by introducing the above-mentioned countermeasures, the company will be able to reap the following benefits:

transformer power factor improvements - 32,100 kWh/y, 1%

If the infrared lamps are put out at times when adequate, while checking the strength of products, then certainly an additional large amount of electric power can be saved.

Report No. 8: Glass

REPORT ON THE DIAGNOSIS

FOR

ENERGY CONSERVATION

- Apa Industry Co., Ltd. -

January, 1983

Japan International Cooperation Agency

Contents

The Diagnosis for Energy Conservation

- Apa Industry Co., Ltd. -

1. Outline of the Factory

Address : 3530 Bang-na Sukhumvit Rd., Bangkok

Type of industry : Glass

Major products : Tooth paste tubes, plastic containers, vial

Annual output : 150 t

No. of employees : 270 (industry) 67 (container) 337 (total)

Annual energy consumption :

- Electric power : 2,316,960 kWh
- Fuel
  - LPG : 15,600 kl
  - O_2 : 68,400 m^3

Interviewees : Varavut juijenrob, and Somsak Suthikavilkul

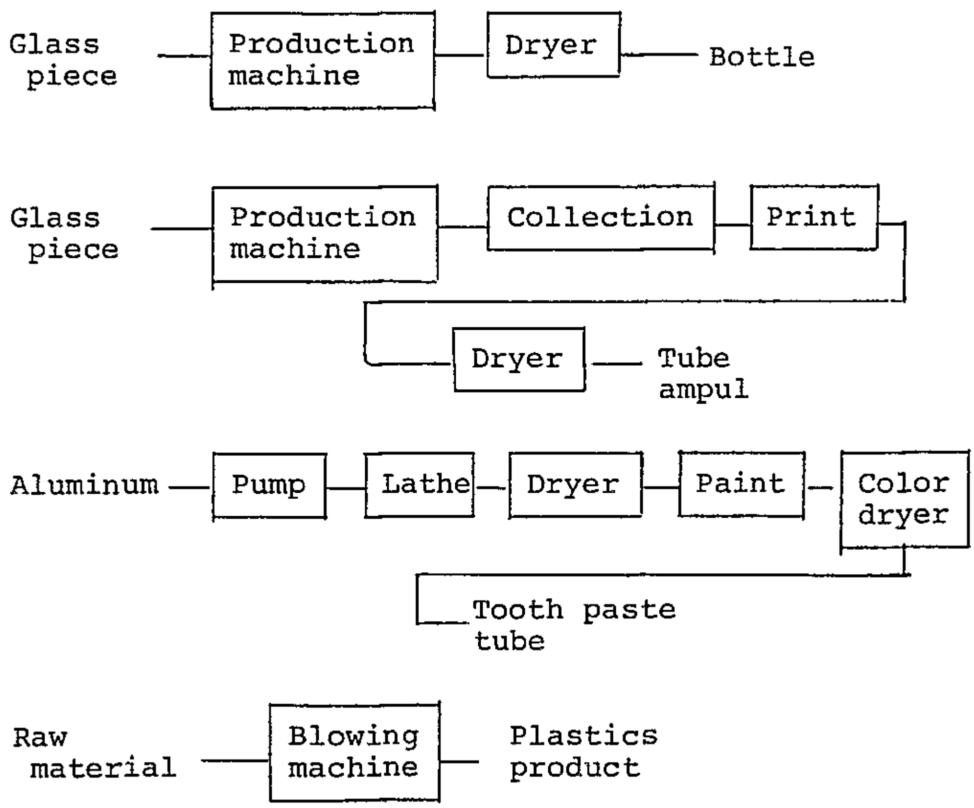
Date of diagnosis : Aug. 30 - 31, 1982

Diagnosers : M. Ito, Y. Ohno, and T. Sugimoto

Ampul, vials and other glass products, aluminum tubes for tooth paste, plastic extrusions and many other products are being manufactured in two factories located on the same premises. These are Apa Industry and Apa Containers. It is a typical processing operation. It imports glass tubes from Japan, for example, to work them up into glass products. No Thai ampul makers are producing more than this factory. This has 12 machines in use.

This is a factory consuming not much energy, but the trouble with it is that it uses more power and oxygen than was designed. Investigations are in progress to probe into the cause of the bad product rate that runs at 20% for glassware and 15% for aluminum tubes.

2. Manufacturing Process

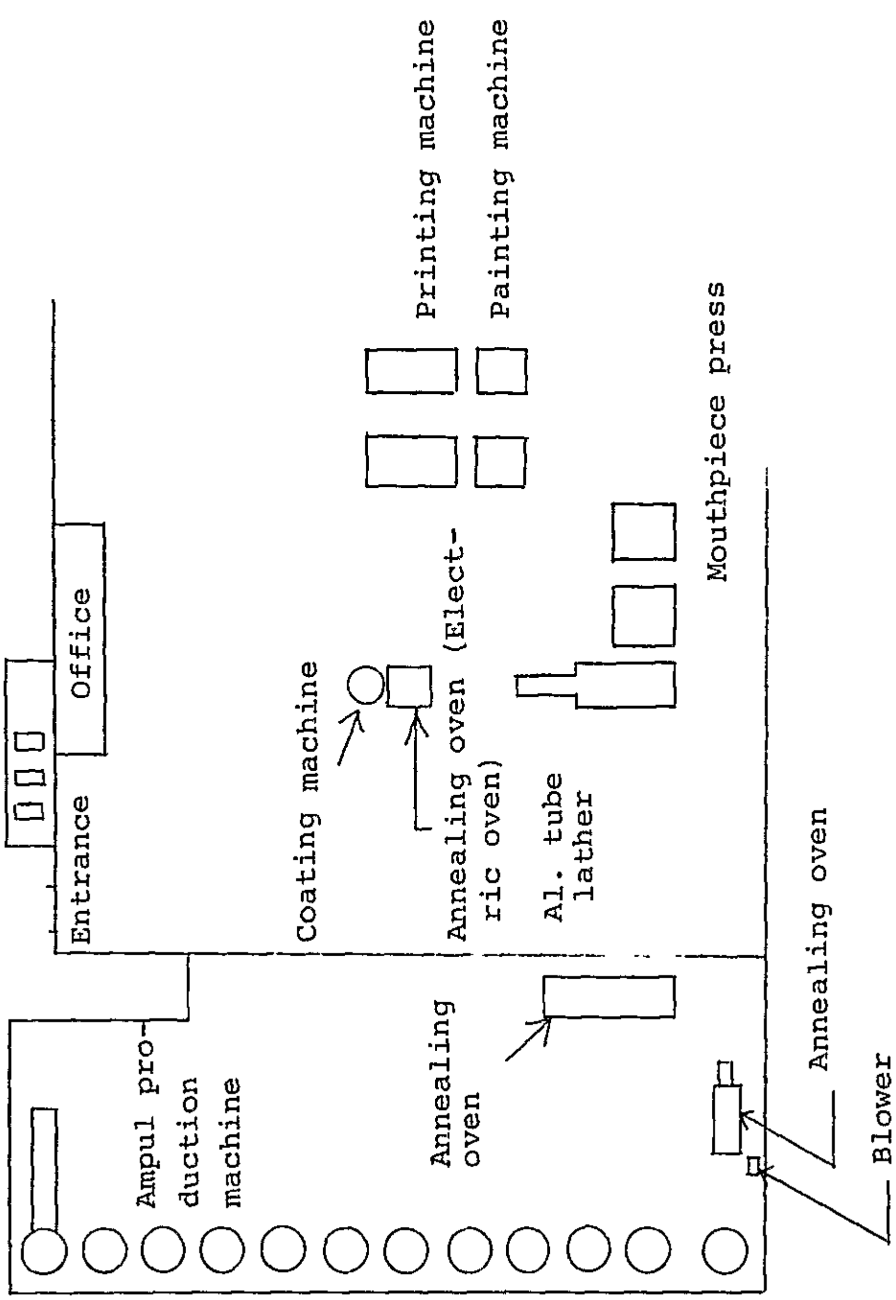


3. Major Equipment

(1) Major equipment

Name	No. of units installed	Type, etc.
Bottle production machine	1	1,800 bottle/h
Glass tube production machine	9	4,500 tube/h x 1 2,300 tube/h x 8
Aluminum tube lathe	3	
Injection machine	2	
Annealing oven	8	LPG heater 3 Electric heater 5

(2) Layout


Printing machine
Painting machine
Mouthpiece press
Office
Entrance
Coating machine
Annealing oven (Electric oven)
Al. tube lather
Annealing oven
Ampul production machine
Annealing oven
Blower

4. State of Energy Management

The total amount of energy consumption is being checked from month to month.

Measurements of consumption had once been taken by size of product, but they do not make a practice of making regular calculations for energy consumption rate.

No systematic energy-saving activities have been developed, but this comes up for discussion from time to time in executive meetings.

No particular education is given to employees except the general education that they receive at the time of their employment.

Quality control is being encouraged with an independent inspection room provided for it.

5. State of Fuel Consumption

Fuel is used in amounts set out below:

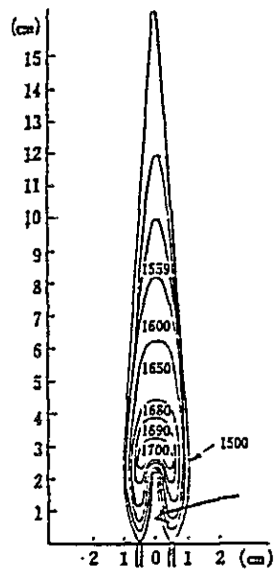
Fuel LPG	-	15,600 kg/y
Oxygen	-	68,400 m^3/y

LPG is used only for making glass bottles and tubes and for annealing. Oxygen is used for combustion in the manufacturing process. LPG has been used for annealing for only two or three months.

6. Problems in Heat Control and Potential Solutions

(1) Burner in ampul production machine

Flames in the ampul production machines other than those introduced recently can be seen taking a long flame, failing to contact the glass in the part where they produce their highest temperature. An example of the thermal distribution of gas flames, set out in the figure below, shows that the temperature is at its highest at a point a few millimeters from the top end of the inner flame. This is the point where what is to be heated in the manufacturing process of ampuls should be adjusted to come.



20% mixed gas (specific gravity 0.50) + air

Flames produced in this factory are somewhat short of oxygen. Supply of more oxygen could produce a shorter inner flame. During our visit there, we happened to see a backfire. Backfires occur when the running velocity in nozzle is lower than the burning velocity.

Supply of more oxygen could boost the burning velocity at a rate that can be expressed by the follwoing formula:

Propan $U_{max} = 45.5 \{9.43(M - 0.21)^{0.88} + 1\}$ cm/s

Butane $U_{max} = 37.5 \{11.3(M - 0.21)^{0.82} + 1\}$ cm/s

Where,

$$M = \frac{O_2}{O_2 + N_2}$$

Given oxygen as 100%, the velocity works out at 394 cm/s and 387 cm/s respectively. So,running velocity of gas in nozzle should be higher than these figures.

Other general measures for preventing backfires:

a. Using more of the smaller and deeper nozzles with the gas pressure at a higher level.

b. Cooling the burner head, or getting it made of ceramic that is hard on heat conduction.

As the nozzles are thought to swell out in inside diameter in this mill, they should be replaced by those of the designed size.

This will help reduce the amount of LPG and that of O_2 and prevent losses by backfire.

(2) Annealing oven

The purpose of the oven is to cool glass in a temperature of about 550°C to let there be no strains in it. Products fresh from the production process are still hot enough, and so should be put in the oven before they cool down. If care is taken, as much as possible, to let no air into the oven, it will not consume very much fuel. Operators are advised to check up on the quality and turn down the burners beginning with the one at the outlet end.

Since most of the heating energy is being used for tray heating, it might be advisable to replace with lighter ones when alterations are made in the future.

7. State of Electric Power Consumption

(1) The principal data relating to power consumption are as follows:

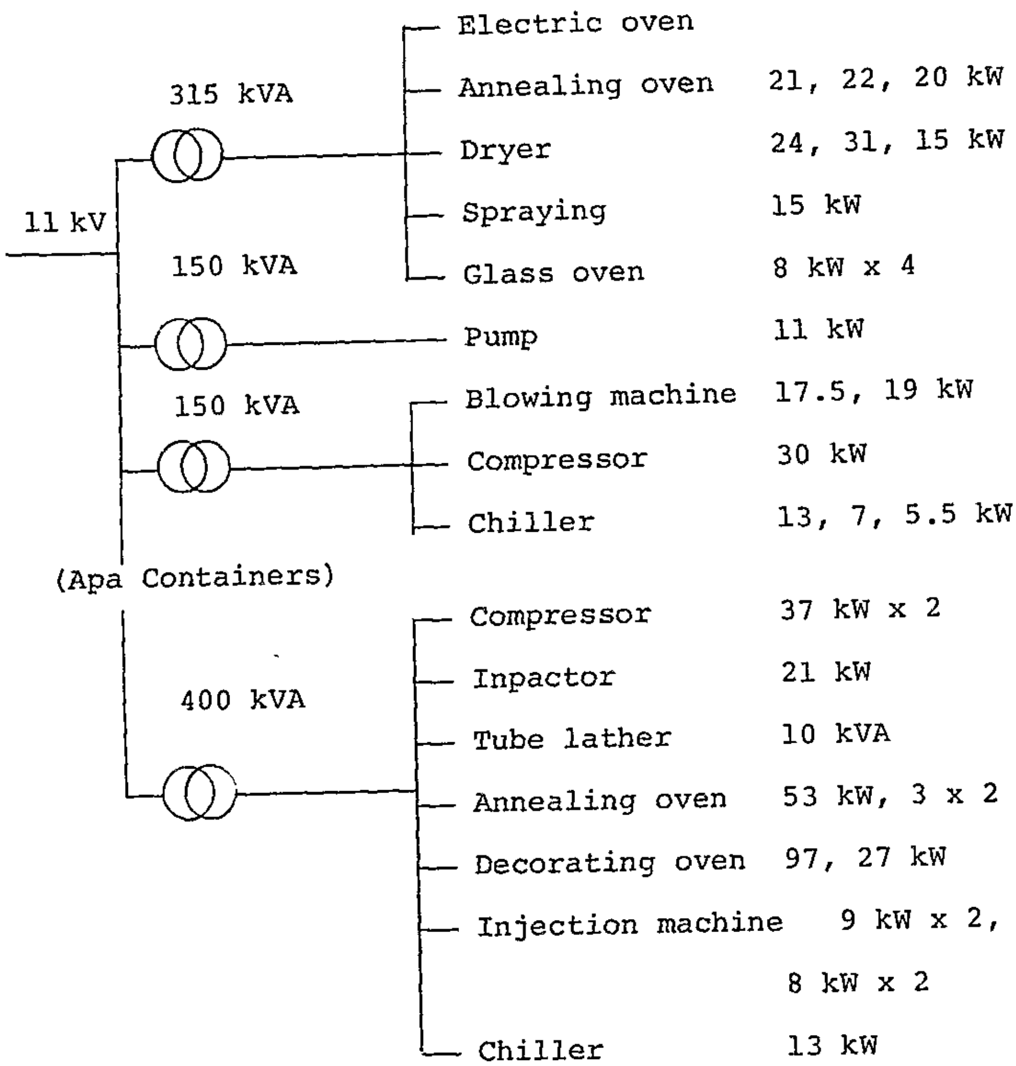
Power company	-	MEA	
Peak demand	-	261 (240) kW	207 (55) kW
Electric power used	-	117,000 kWh/m	47,700 kWh/m
Load facotr	-	62.2%	
Penalty	-	97 kVr	5 kVr
Power factor	-	71 (86)%	(83)%
Transformers	-	315 kVA x 1 150 kVA x 2	400 kVA x 1

Note: The figures on the left relate to Apa Industry and those on the right to Apa Containers.

In parentheses are the figures we found the day we were there.

(2) One-line diagram

(Apa Industry)



Apa Industry has electric ovens covering 67% of its 240 kW load capacity and also has heaters for use in its plastics division. That is why, it would seem, they have much of the unbalanced current that has an adverse effect on the power source and load.

We found the annealing ovens to have a surface temperature of about 40°C, radiating heat at the rate of 180 - 210 kcal/m^2 h, low enough for proper heat insulation.

8. Problems in Electric Power Control and Potential Solutions

(1) Transformer

Apa Industry has three transformers all high in secondary voltage (397 - 408 V). The third transformer for use in the plastics shop has a low power factor (78%).

A tap change in the transformer bringing the secondary voltage to about 390 V would be able to reduce the transformer loss a little and improve the power factor a little.

We saw some puddles on the rooftop where the transformers were installed. The puddles should be drained at early stage. They could lead to corrosion of the transformer case or could cause an electricity leakage.

(2) Power factor

A low overall power factor seems to arise from the small light-load motor in the plastic shop.

Closer investigations should be made so that the motor will be replaced by one of a proper capacity.

(3) Electric oven

A heat loss occurs at the oven inlet and outlet. Openings should be covered until they remain as small as possible, so as to minimize heat losses from radiation and convection.

This will save 5 - 7% (about 10 kW) on all the electric ovens and achieve a saving of about 57,000 kWh a year of electricity.

10 kW x 16 h/d x 360 d/y ≒ 57,000 kWh

(4) Air-conditioning of blowing machine room

In the rooms in which heater-fitted machines are installed, it might be advisable, as far as possible, to set a higher temperature for room cooling or restrict cooling to the smallest possible sections, so that the load of air-conditioning will be reduced. This would also help reduce the load of heaters.

(5) Wiring for Blowing Machine

A large flow of current in the neutral lines (20%) is responsible for unbalanced currents.

Lines should be connected in such a way as to carry a balanced load, and the motor is prevented from developing abnormal heat or vibrations.

Report No. 9: Ceramic

REPORT ON THE DIAGNOSIS

FOR

ENERGY CONSERVATION

\- Siam Insulator Co., Ltd. -

January, 1983

Japan International Cooperation Agency

Contents

The Diagnosis for Energy Conservation

- Siam Insulator Co., Ltd. -

1. Outline of the Factory

Address : Bangchan Industry Area, No. 1-2 and 15-18, Bangkok-Meanfuri Rd. Meanfuri, Bangkok

Capital : 25 million bahts

Type of industry : Ceramics

Major products : Insulator, lighting arrestor

Annual output : 4,200 t

No. of employees : 200

Annual energy consumption :

- Electric power : 1,032,000 kWh
- Fuel

  Kerosene : 1,440 kl

Interviewees : Sombratana Bonnag, chief engineer, and Somrak Watananusan, vice president (Technical)

Date of diagnosis : Sept. 6 - 7, 1982

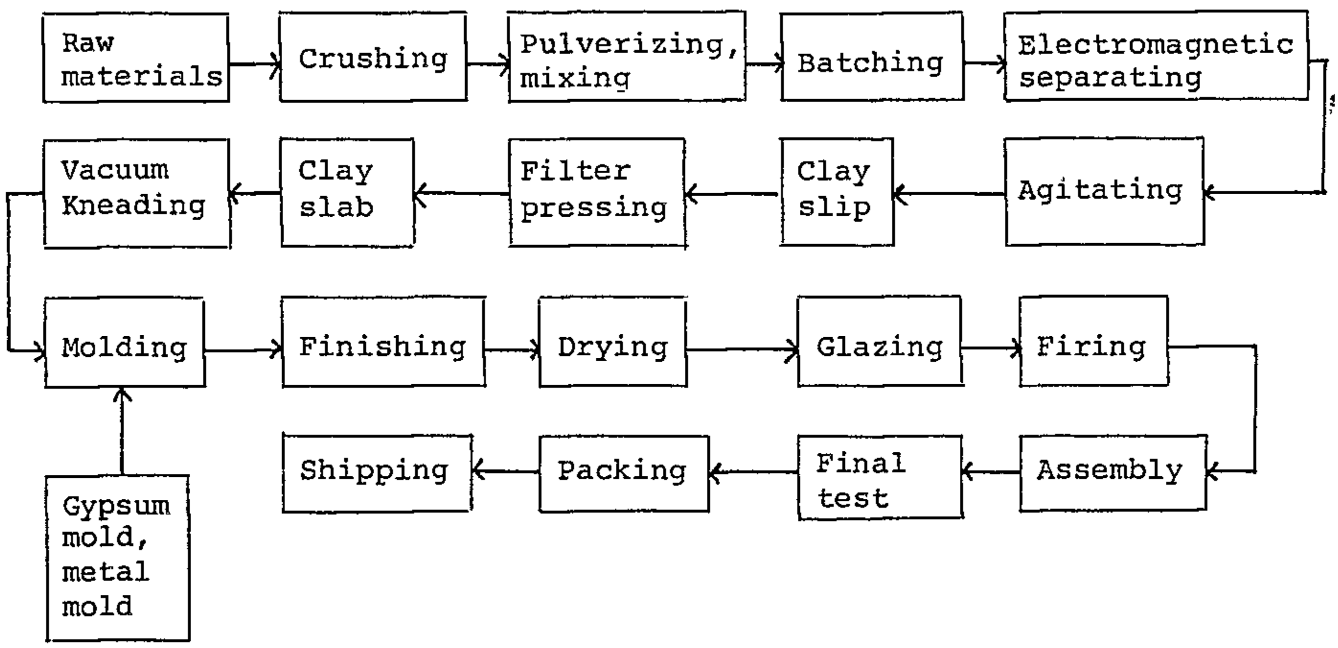
Diagnosers : M. Ito, Y. Ohno, and T. Sugimoto

No Other Thai manufacturers can produce more high-pressure insulators. Modern and beautiful designs on the buildings of this factory make it stand out in the Bangchan Industrial Area where it is located -- a 40 minutes' car ride north-east of central Bankgkok. Various kinds of insulators have been turned out during the seven years it has been in operation. Scouring the country over for the good raw materials they need, they are taking great pains.

Energy conservation is a company policy they pursue. Kilns with a ceramic fiber lining they have introduced permit them to complete the firing process in 24 hours instead of 40 hours it took. A dryer they have additionally introduced this year is designed to work utilizing some waste heat from the kilns.

2. Manufacturing Process

High-Pressure Insulator Production Flow Chart

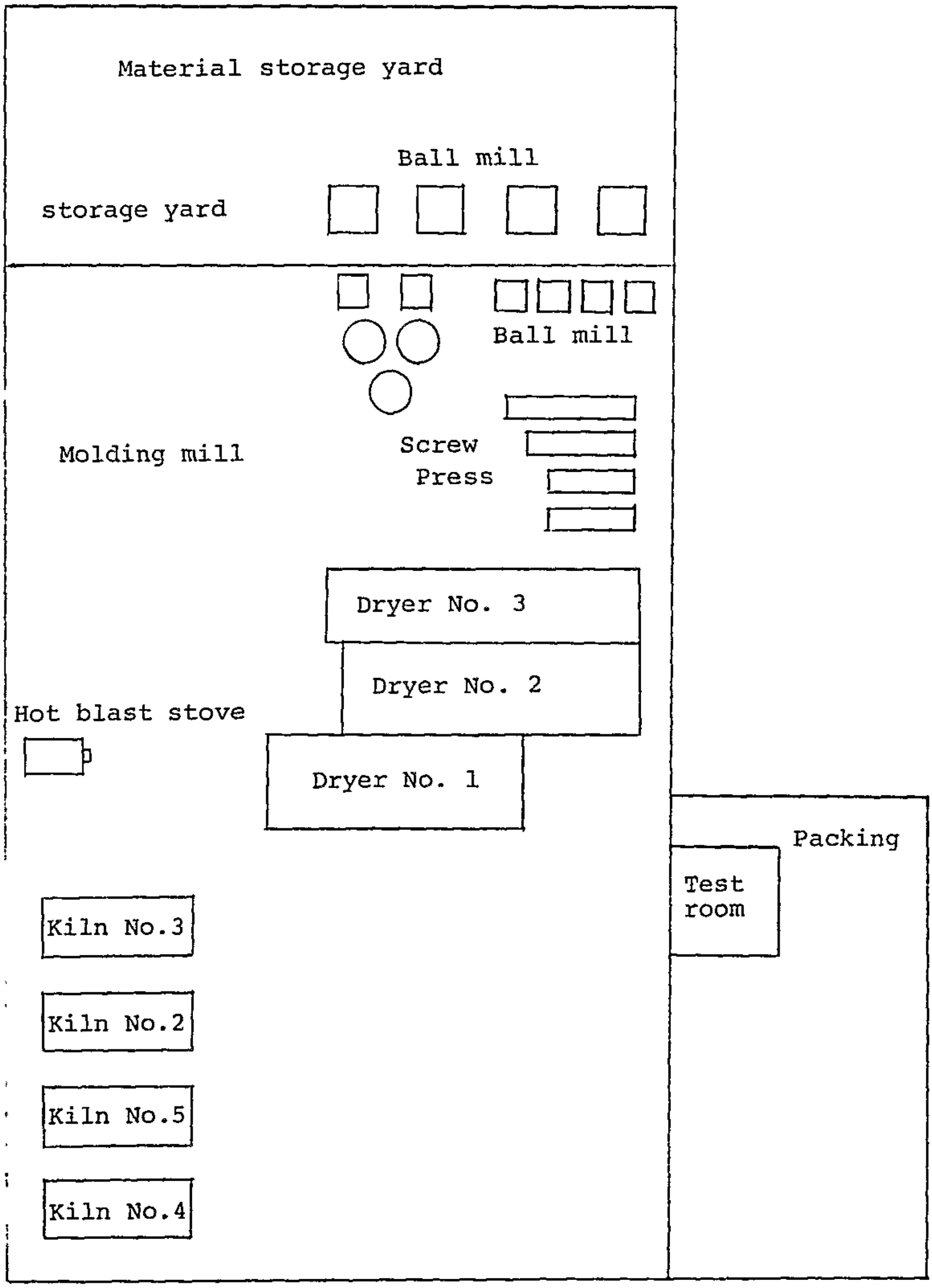


3. Major Equipment

(1) Major equipment

Name	No. of units installed	Type, etc.
Ball Mill	10	22kW x 4, 7.5kW x 4, 3.7kW x 2
Screw Press	4	7.5kW
Dryer	3	Use of shuttle kiln waste gas and hot blast
Kiln	4	Shuttle kiln, ceramic fiber lining 10 T/batch, car trucks 10 Burners 22 2 out of operation

(2) Layout


Material storage yard
Ball mill
storage yard
Ball mill
Molding mill
Screw
Press
Dryer No. 3
Dryer No. 2
Hot blast stove
Dryer No. 1
Packing
Test
room
Kiln No.3
Kiln No.2
Kiln No.5
Kiln No.4

4. State of Energy Management

Energy conservation is a company policy to be pursued, but goals are yet to be set for it. They have prepared equipment-level statistics for the thermal end of energy consumption, but factory extension work has kept them busy to collect figures for the electric end.

Energy consumption rates are known, but they have not come to the point of Japan where control charts are made. They make a cost accounting once a month, but they have never made accounting by process, nor have they ever made a thermal accounting of the kilns. They say they like to do so if they learn the method.

No energy-saving organization has been set up. They would like to introduce the improvement suggestion system that is successful in Japan, though not yet implemented. No on-th-job training for employees is under way; all that has been done is to have staff members attend TPA seminars.

5. State of Fuel Consumption

The fuel is kerosene. Most of 1,440 kl/y is used for firing, and some for generating hot blast.

Thermal efficiency η of the kiln comes out low under the following conditions:

Given:

Burned product - 5,300 kg/batch

Burning temperature - 1,280°C

Burned product specific heat - 0.31 kcal/kg °C

Fuel consumption - 2,400 liters/batch

Fuel calorific value - 8,245 kcal/liter (9,600 kcal/kg)

$$\eta = \frac{5,300 \times (1,280 - 30) \times 0.31}{8,245 \times 2,400} \times 100 = 10.4\%$$

This is due to the fact that large quantities of heat are required for the kiln body and carriage, etc. to warm them up and that hot waste gas is discharged as it is. Heat of waste gas are used as a drying heat source only in oxidation period.

6. Problems of Heat Control and Potential Solutions

(1) Quantity of heat release from kiln side walls.

Findings on the quantity of heat release from kiln No. 4 show:

Heat flux (average)	- 1,133 kcal/m^2h
Surface temperature	- 110°C
Kiln surface area	- 122.6 m^2
Quantity of heat release	- 1,133 x 122.6
	= 139,000 kcal/h

This is equivalent to 17 liters/h of oil.

Since the surface is covered by iron plate, it is difficult to insulate the surface. It might be advisable to fill in insulating material if there is a space between iron skin and brick.

The inside, already provided with a ceramic fiber lining, might give some problems such as the work itself, shrinkage of inner capacity of kiln, etc., but there is still some space for increasing thickness from economical viewpoint.

(2) Burning control

Since the oil burner was not set in the right position as opposed to the center of the burner tile, we saw flames hit the burner tile, causing carbon to arise and giving rise to pulsations, or flames flow outside.

It appeared that good care was being taken to make fuel adjustments. We hope adjustment will be made to the burner position as well.

It might be advisable to fit a simple support on the iron skin, because there is a problem in the burner being supported by a flexible tube that is too soft.

(3) Utilization of heat from waste combustion gas

Waste combustion gas coming out of the kiln in a high temperature is used as a dryer heat source at the oxidation period. but waste heat is not fully utilized as the piping is not insulated. A better use will be found for waste heat and economy practiced in fuel if the waste gas line is fitted with a heat exchanger to heat the air so that it will be used as combustion air and as a dryer heat source.

Let us, for instance, find the fuel saving effect when air is heated to 200°C.

Given that the average air ratio for all the oxidization and reducing periods is 1.1, Quantity of air required (A) $= \left\{ \frac{0.85 \times 9,600}{1,000} + 2.0 \right\} \times 1.1 = 11.2$ Nm^3/kg of oil

Increased quantity of heat of heated air

$$11.2 \times (200 - 30) \times 0.31 = 590 \text{ kcal/kg of oil}$$

$$\frac{9,600 - 590}{9,600} = 0.94$$

Therefore, there will be a saving of 6% in fuel.

(4) Lighter carriage

If some of the firebricks on the carriage top are replaced by insulated firebricks, heat will be blocked from going down below the floor, so that the same quantity of fuel that has been in use will be enough to remarkably raise the internal temperature of the kiln. This will make for energy conservation. In Japan, this achieves a saving of 5-8% of energy.

(5) Improvement in carriage control

a. Bricks push out in sections where carriages are connected.

b. A distorted steel skirt beneath the carriage fails to keep close connection to the neighboring carriages.

c. Sand runs out from sealed parts beneath the carriage.

These defects must be made good and the sand must be replenished to bar cool air from invading the kiln. Efforts should be made to gradually reduce the quantity of air to be blown in.

(6) Close kiln door after firing work

The quantity of heat for warming up the kiln system amounts to some 25% of the total in the shuttle kiln. If the door is left open after carriages have been pulled out on completion of firing work, there will be a great heat loss. It might be advisable to improve the way carriages move into and out of the kiln so that the door will not be left open for a long time.

(7) Merit in fuel switchover

By reason of quality and price, the company is now using kerosene which does not differ much in cost from A heavy oil. Kilns of the kind they have are generally supposed to use A heavy oil. While striving for higher manufacturing technology to make up for quality, they might be able to change for A heavy oil that is less costly, though slightly. This might be a good cost-cutting step as it means a fuel cost saving of 1.44 million bahts a year.

(8) Even temperature within drying room

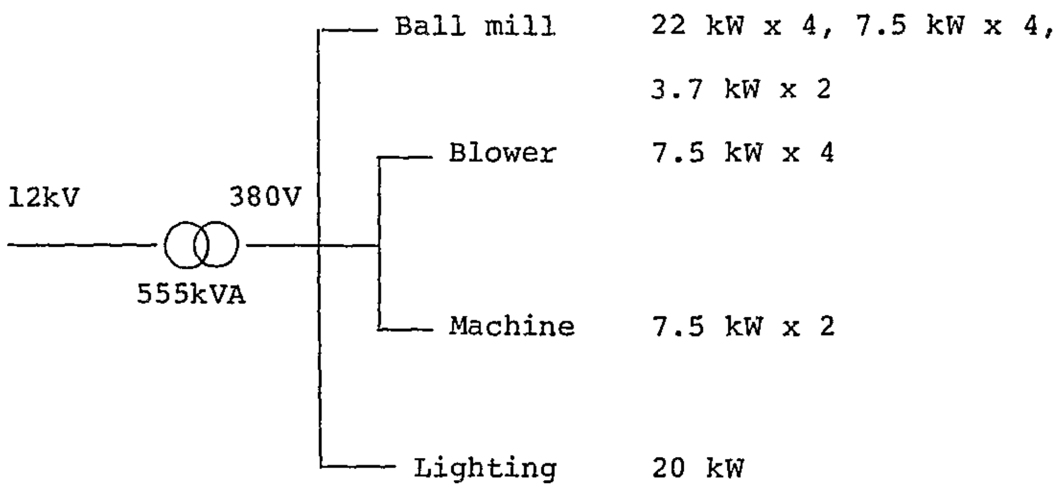
The blowers installed now were found to be in a position too close to the wall for hot air in the dryer to circulate smoothly. It is necessary to re-examine the way they are installed and the number of them in operation.

7. State of Electric Power Consumption

(1) The principal data relating to power consumption are as follows:

Power company	-	MEA
Peak demand	-	183 kW
Electric power used	-	85,200 kWh/m
Load factor	-	85.6%
Penalty fee	-	15 kVr
Power factor	-	62% (65% as measured actually)
Transformer	-	555 kVA

(2) One-line diagram



8. Problems in Electric Power Control and Potential Solutions

(1) Power factor

A small motor circuit light load (55%) is responsible for the power factor standing as low as 65%.

Installation of two 50 kVr condensers would move up the power factor to 85%.

This would produce the following effects:

o A smaller transformer copper loss: as the current declines from 351 A to 268 A,

$$555 \times (1 - 0.98) \times 0.8 \left\{ \left(\frac{351}{843}\right)^2 - \left(\frac{268}{843}\right)^2 \right\}$$

$$8{,}640 = 55.2 \times 10^3 \text{ kWh/y}$$

o No need for penalty fees.

1,875 b/M x 12 = 22,500 bahts/y

The cost of installing condensers is about 30,000 bahts, which will be recovered within 6 months.

(2) Overloaded ball mill motor

The motor in the 4-ton ball mill is overloaded. After a 25 HP motor was replaced by a 30 HP motor, an increased charge made it overloaded again. Charges must be restricted to the normal level in order not to shorten the lives of the motor and the mill bearing.

(3) Equipment maintenance

Slackened ball mill belts, dirty lamps and broken switches were observed.

No accurate one-line diagram is available.

9. Summary

If the measures are taken as set out above, energy conservation will be achieved as follows:

Item	Quantity	%
Preheating of burning air	86 kl/y	6
Insulation of carriage	115 kl/y	8
Subtotal	201	14
Improvement of power factor	55,200 kWh/y	5

Report No. 10: Ceramic

REPORT ON THE DIAGNOSIS

FOR

ENERGY CONSERVATION

- Armitage Shanks (Bangkok) Co., Ltd. -

January, 1983

Japan International Cooperation Agency

Contents

The Diagnosis for Energy Conservation

- Armitage Shanks (Bangkok) Co., Ltd. -

1. Outline of the Factory

Address : 33 Khor, Viphavadee Rangsit Rd., Don Muang, Bangkok

Capital : 90 million bahts

Type of industry : Ceramic

Major products : Sanitary ware

Annual output : 220,000 units

No. of employees : 225 (160 at present)

Annual energy consumption :

- Eelctric power : 2,034,000 kWh
- Fuel
  - Fuel oil : 1,806 kl
  - Diesel oil : 8 kl
  - LPG : 48 kl

Interviewees : Prakob Prohmvitak, B. Sc. (Chula) in Chem. Eng.

Date of diagnosis : Sept. 15 - 16, 1982

Diagnosers : Y. Ohno, T. Sugimoto

The factory is located about 40 minutes by car, north-northeast of Bangkok's center city area, facing the highway that leads to the airport. Construction of the plant facilities began in 1969, and the production line began operating in 1971. Following the start of operations, there was a shrap increase in demand, and the company's capitalization was increased to the current level of 90 million bahts to meet the demand. The company is a joint-venture with a British company, which owns 10% of its stock, and it also has a technical tie-up with its overseas investor. People from the U.K. firm come to the plant on the average of once or twice per month, however there is no one there from the British firm on a stationary basis.

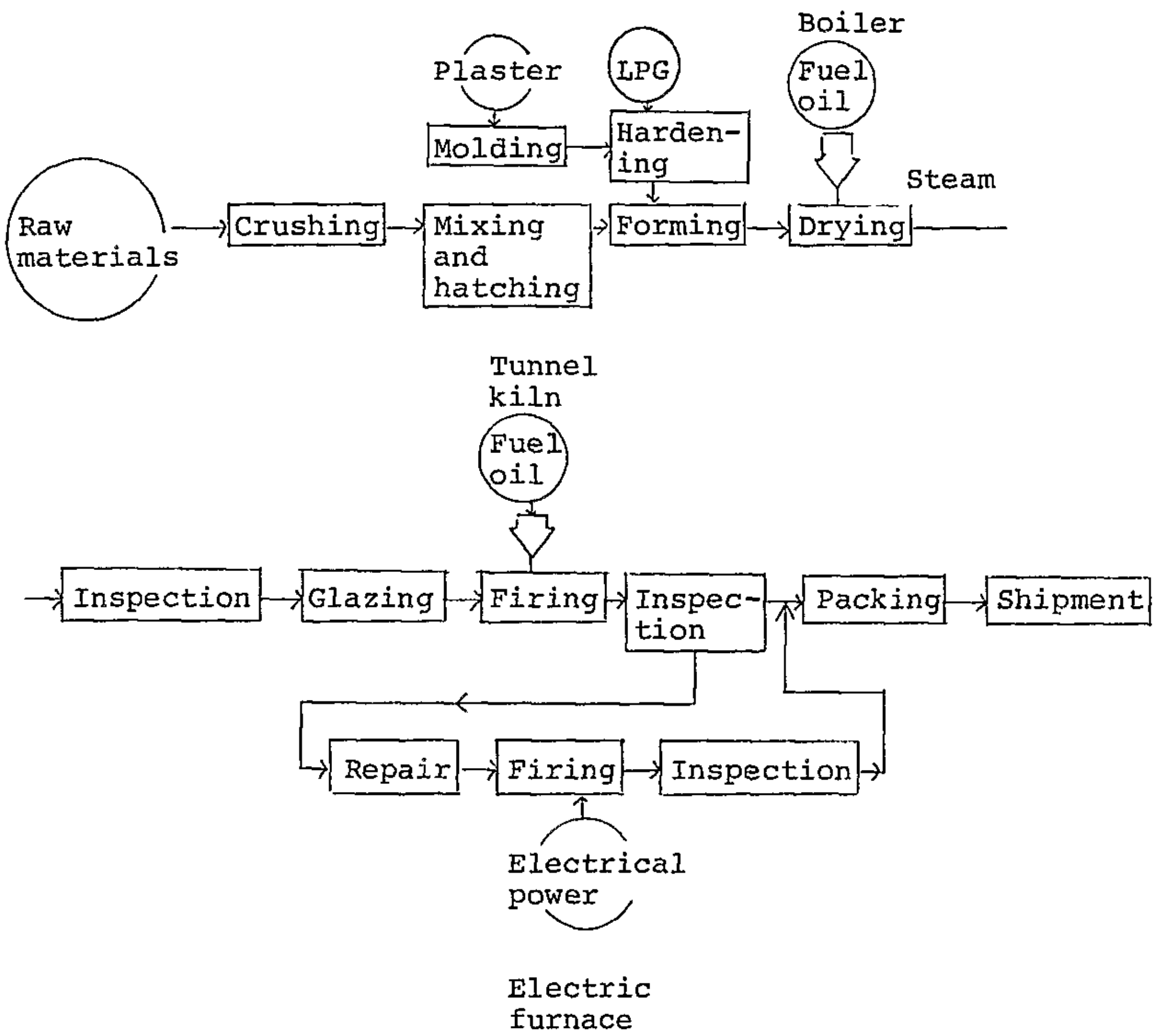
When operations are going on at their fullest level, the plant employs 225 workers. But currently the facility is operating at only 40% of total capacity, and there are only 160 workers on hand. While all of these workers work there on a full time basis, only the company's management staff is paid on a monthly salary basis.

There are now a total of four companies in Thailand that make sanitary ware, but this company and American Standard are the only one's that make high-class wares, and each of these has about half the market. The other two manufacturers hardly account for any of the high-class wares market at all. But the competition between each other and American Standard is extremely tough, and despite increases in the cost of energy the companies are unable to pass these increase along in the form of price hikes.

The company expresses production quantities in the form of "number of units," rather than in tons. There are many different sizes and shapes in its product line, rather than there being a fixed size and shape, and as a result the production cost by type is unclear. However, the company does keep track of average unit costs.

Although the facility has a capacity to produce 1,500 units per day, production is currently down to only 40% of total capacity.

2. Manufacturing Process

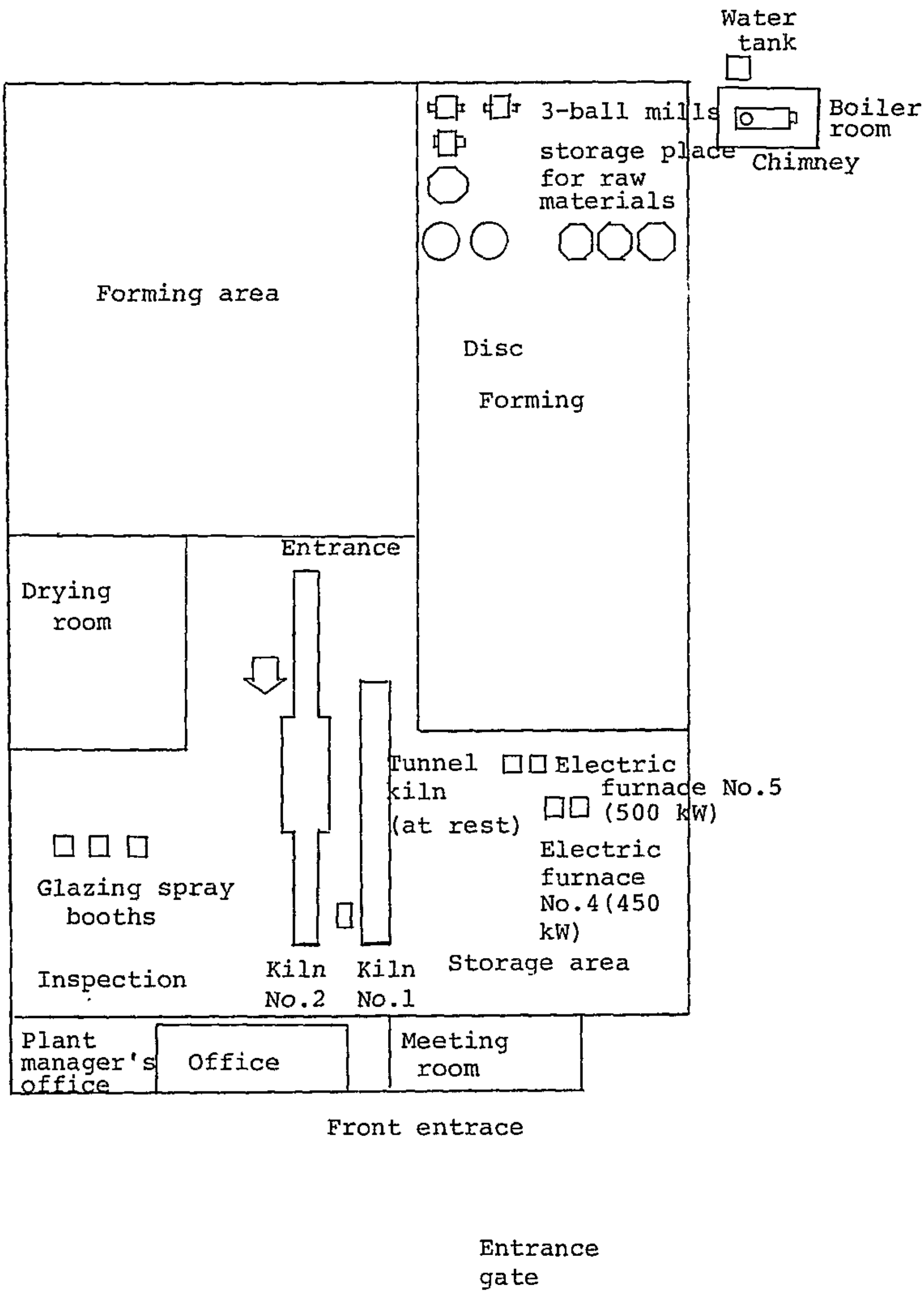


3. Major Equipment

(1) Major equipment

Name	No. of units installed	Type, etc.
Ball mill	3	
Tunnel kiln	1	Muffle type, Drayton
Tunnel kiln	1	Gibbons (at rest)
Electric furnace	2	Donald Shelly, Top hat type; 500 KW, 450 kW
Boiler	1	Flue and fire-tube type, 2 t/h, 7 kg/cm^2 G

(2) Layout


Water tank
3-ball mills
Boiler room
storage place for raw materials
Chimney
Forming area
Disc
Forming
Entrance
Drying room
Tunnel kiln (at rest)
Electric furnace No.5 (500 kW)
Electric furnace No.4(450 kW)
Glazing spray booths
Inspection
Kiln No.2
Kiln No.1
Storage area
Plant manager's office
Office
Meeting room
Front entrace
Entrance gate

4. State of Energy Management

The company is extremely concerned about saving energy. Already they have introduced such energy saving measures as improving insulation at the top of the tunnel kilns' carriages, and that of electric furnaces (by using ceramic wool), and utilization of hot air from the kiln cooling zone as combustion air; and they also plan to use the excess hot air for drying purposes. However, the company has no specifically decided targets for the amount of energy to be saved.

The amount of energy consumed by the entire plant daily is measured and checked. The company also performs a production cost analysis, however there is no analysis of the energy cost for each separate manufacturing process segment. Measuring for heat control purposes is not done, except by coincidence when boiler exhaust gas is checked for level of CO_2 concentrations, and a heat balance chart has never been made.

The comapny has never conducted any organized activities or established any special committees or project teams for the purpose of studying or conducting energy saving activities. To date, the only energy-saving activity that has been done has resulted from the manager's appeal to employees to save energy in various ways. There have not been many suggestions from the employees about how to save energy. Emplyee training in energy saving to date has been limited to sending some three persons to TPA. It has been agreed that they should establish QC circles, and preparations to do this are underway.

There are some opportunities for top level management to exchange ideas with their counterparts in other companies in regards to energy saving measures, however so far there has not been any very deep discussion of this kind as both sides seem to hesitate discussing such matters in depth with other memebers of their industry. In the past there had been a program of making tours of each other's factories, but this is no longer being conducted.

5. State of Fuel Consumption

The annual consumption of fuel oil is about 1,806 kiloliters, of which the majority is used for the tunnel kilns. The boiler is only used during low-temperature periods.

The thermal efficiency of the plant's manufacturing process breaks down as follows:

- Average weight/unit - 14 kg
- No. of units produced/year 220,000 units
- Firing temperature - 1,130°C
- Specific heat of formed products - 0.337 kcal/kg °C
- Consumption of fuel oil - 90% of 1,806 kl/y (1,694 t/y)
- Heat contents of fuel oil (Hl) - 9,692 kcal/kg

Based on these figures, the efficiency of kilns (η) is as follows,

$$\eta = \frac{14 \times 220{,}000 \times (1{,}130 - 30) \times 0.337}{1{,}694{,}000 \times 9{,}692 \times 0.9} \times 100 = 7.7\%,$$

which is a rather low figure.

This kiln is a so-called muffle type kiln with very little heat exchange taking place in the preheating zone so the exhaust gas temperatures come high.

6. Problems in Heat Control and Potential Solutions

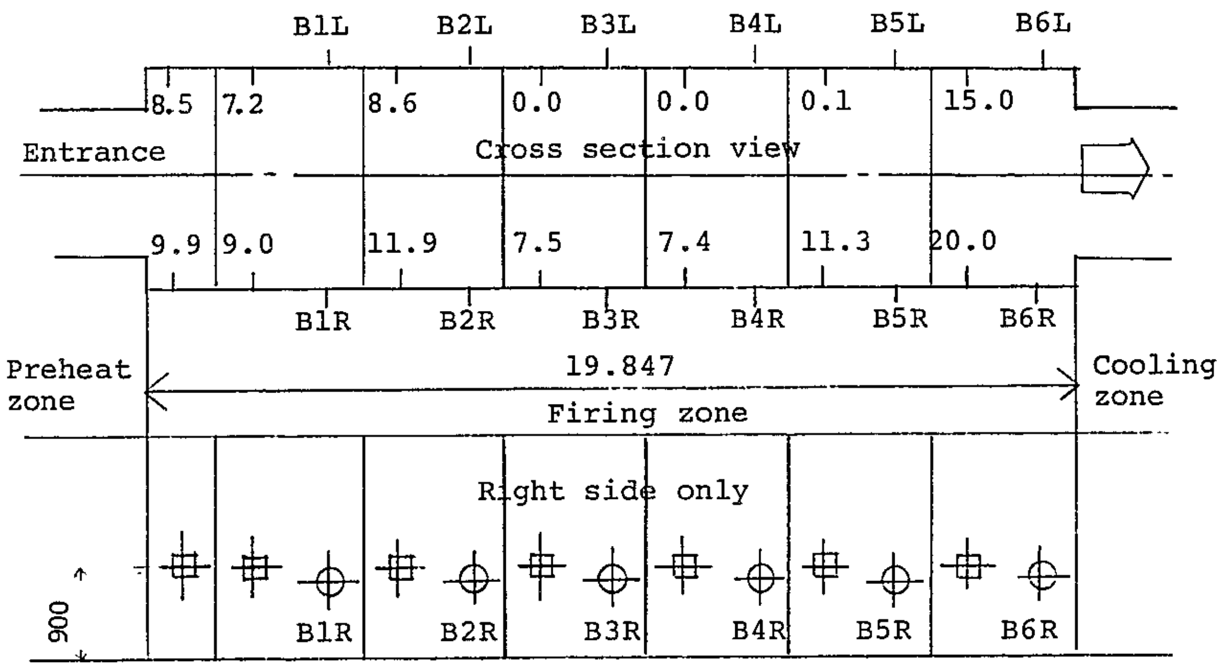
(1) Improvement of heat control in the tunnel kilns

As the result of measurements of the distribution of oxygen concentration in the firing zone of muffle-type tunnel kilns, it was realized that there is a considerable difference in the amount of oxygen in the muffler on the same position on opposite sides of the kiln. (See figure below for more details.) This reflects the fact that the flow of combustion gas is not even throughout the muffler, therefore causing exhaust gas losses and uneven firing due to incomplete combustion and a lowering of the flame temperature.

It is therefore desirous that each burner burn evenly which can be achieved through the following improvements:

- Adjustment to the inlet damper of the induced draft fan;
- Adjustment of the oil burner's secondary air damper; and
- Periodical analysis of exhaust gases with an oxygen analyzer.

Distribution of Oxygen Concentration inside of Tunnel Kiln Firing Muffler



The percentage of oxygen at the firing zone exit is an average 9.2%, and the air ratio is $m = \frac{21}{21 - 9.2}$ = 1.78, showing that close to the exit a lot of air is sucked in.

The following is a calculation based on improving the air ratio to m = 1.3:

Theoretical amount of air (Ao) $= \frac{0.85\ Hl}{1{,}000} + 2.0$

$= 10.2\ Nm^3$/kg of oil

Theoretical amount of exhaust gas (Go)

$= \frac{1.11\ Hl}{1{,}000} = 10.8\ Nm^3$/kg of oil

Heat contents of oil $Hl = 9,692$ kcal/kg

Actual amount of exhaust gas

$G = Go + (m - 1)\ Ao = 10.8 + (m - 1)\ 10.2\ Nm^3/kg$ of oil

- in the case where $m = 1.78$, $G_1 = 18.8\ Nm^3/kg$ of oil
- in the case where $m = 1.3$, $G_2 = 13.9\ Nm^3/kg$ of oil

As the temperature of exhaust gas is more than 500°C, an accurate measurement was not posible on the day.

But assuming that this temperature is 700°C, the exhaust gases will take away the following amount of heat:

$$Q_1 = 18.8 \times 700 \times 0.33 = 4,343 \text{ kcal/kg of oil}$$

$$Q_2 = 13.9 \times 700 \times 0.33 = 3,211 \text{ kcal/kg of oil}$$

Accordingly, the amount of fuel used falls to

$$(\frac{9,692 - 4,343}{9,692 - 3,211}) = 0.82.$$

The amount of fuel saved annually equals:

$$1,806 \text{ kl/y} \times 0.9 \times (1 - 0.82) = 292 \text{ kl/y}.$$

(2) Using exhaust heat from the kilns

Even if the air ratio is improved, some 600,000 kcal/h of heat is exhausted with the combustion exhaust gas.

On the other hand, the boiler in the drying room produces steam from which it is desirable to use the exhausted heat. The following are two possible ways that this could be undertaken:

- Install a heat transfer recuperator with about 80 m^2 area to produce hot air, and interchange this with the cooling zone air and use for combustion. The cooling zone air is sent to the drying room. If the heat of exhaust gas is recovered up to 250°C, an equivalent of 1,651 kcal/kg-oil worth of heat can be recovered through this countermeasures. In this case, the temperature of the air will rise to about 530°C, therefore it is necessary to consider whether or not the burner can withstand such high temperatures.
  If and when the currently pre-heated air temperature reaches 50°C, the energy saving effect will equal:

$$\frac{9,692 - 3,211}{9,692 + 1,651 \times \frac{480}{530} - 3,211} = 19\%$$

- Install a waste heat boiler and recover steam for use in the drying operation.
  The amount of steam recoverable equals $\frac{1,651 \times 190}{(661 - 50)}$ = 513 kg/h, which if used on an average hourly base will be equal to approximately the same amount of steam being used now.

(3) Boiler improvements

On the day of our inspection, the boiler was not in operation and we could not make any measurements. But as the result of our inspection of the boiler room we would like to make the following improvement suggestions:

- To insulate the condensate recovery tank;
- To recover the exhaust heat (gases now are some 400°C); and
- To insulate the man-hole at the rearside of boiler.

(4) Other coutermeasures

For the steam trap of the drying room, it would be best to use a thermostatic trap that can also utilize heat of condensate.

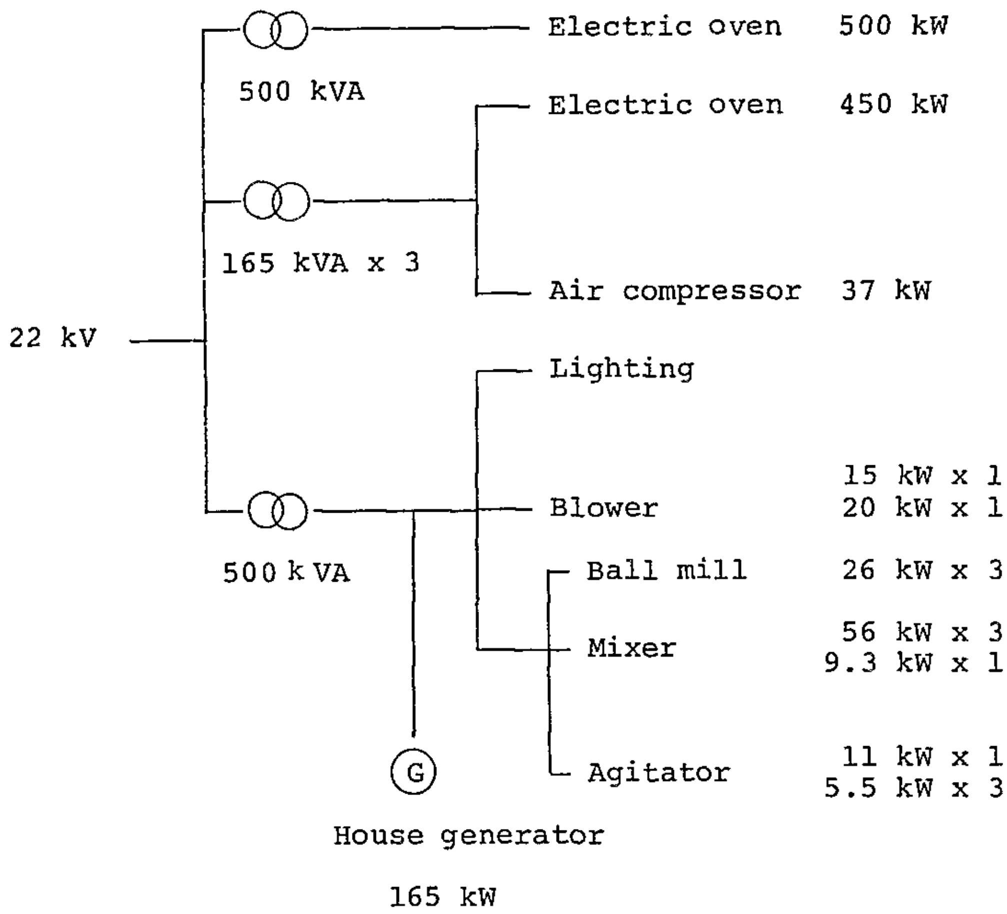
The heat efficiency of the muffler-type tunnel kiln is not good, therefore it has become popular nowadays to replace these kilns with direct-heat kilns.

7. State of Electric Power Consumption

(1) The principal data relating to power consumption are as follows:

Power company	-	MEA
Peak demand	-	600 kW
Electric power used	-	170,000 kWh/m
Load factor	-	39.4%
Penalty	-	No penalty
Power factor	-	84% (actual measurment)
Transformer	-	1,501 kVA

(2) One-line diagram



8. Problems in Electric Power Control and Potential Solutions

(1) There was a strong electric current of 300-600 A going on and off at the electric oven, which is causing large amount of cupper loss in transformer It would be more economical to split this current into two -- a continuous current and an on-off current.

(2) The ball mill is operated only at night, and this helps reduce the peak demand.

As same of driving belt are loose or touching the cover, efforts should be made to put them in good order.

(3) The load on the mixer is conspicuously low (22%). If the load is always low like this, it would be more efficient to change the motor from the present 56 kW one to a 36 kW motor. If two of the three motors now used were replaced with such smaller ones, the reduction resulting in power loss would equal:

$$\left\{56 \text{ kw} \times 0.1 - 36 \text{ kw} \times 0.08\right\} \times 2 \times 5 \text{ h/d} \times 330 \text{ d/y}$$
$$= 9 \times 10^3 \text{kWh/y}$$

(4) The compressor is now overloaded by 16%, making the temperature of the motor high. By reducing pressure of the compressed air as much as possible, as well as by avording leakage and misuse, the load on the compressor should be lowered. The voltage on the compressor is also too high (399V), so it is necessary to change the tap on the transformer and modify it to 380V. By this, efficiency and power factor of motor will be improved.

(5) There are many light bulbs burnt out, dirty covers and lights not switched off.

(6) The holes of the glazing work stand should be cleaned in order to reduce resistance. Moreover, the holes should be covered when the stands are not in use.

9. Summary

The above remedial measured, if actually taken, will bring about energy-saving effects as shown below:

Measures	Potential energy saving	Rate (%)
Improvement of air ratio	292 kl/y	16
Utilizing the heat exhausted from the tunnel kiln	307	17
subtotal	599 kl/y	33
Reducing the capacity of the mixer motor	9×10^3 kWh/y	-

Report No. 11: Paper

REPORT ON THE DIAGNOSIS

FOR

ENERGY CONSERVATION

- Hiang-Seng Fiber Container Co., Ltd. -

January, 1983

Japan International Cooperation Agency

Contents

The Diagnosis for Energy Conservation

- Hiang-Seng Fiber Container Co., Ltd. -

1. Outline of the Factory

Address : 110/G Area 4 Tambol Ban-koh Town District
Samut-Sakorn Post Number 74000

Capital : 150 million bahts

Type of industry : Paper

Major products : Kraft paper, liner board, multi wall
shopping bag

Annual output : 60,000 t

No. of employees : 400

Annual energy consumption :

- Electric power : 36,000,000 kWh
- Fuel
  - Bunker oil : 10,500 kl
  - Diesel oil : 50 kl
  - Kerosene : 100 kl
  - Gasoline : 10 kl

Interviewee : Dr. Chavalit, factory manager

Date of diagnosis : Sept. 6 - 7, 1982

Diagnosers : A. Koizumi, K. Nakao, and K. Kurita

They have a two-line paper machine, but No. 1 line is out of operation and is being converted to make special paper. No. 2 line, built ten years ago and overhauled five years ago, is functioning well with a production capacity of 200 t/d.

An accuracy system is employed with a computer to maintain the moisture and weight control of paper.

Some 600 million bahts has been appropriated for the construction of No. 3 line with a machine speed of 600 m/s and a production capacity of 300 t/d, which, when completed, will push this company ahead of Siang Kraft Paper for top position.

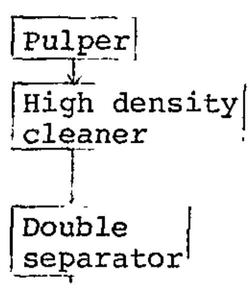
Along with the construction of No. 3 line, work is in progress on a high-pressure boiler (83 kg/cm^2, 84 t/h) equipped with a back pressure turbine generator (12, 000 kW). Investment in this equipment will be recovered in not more than three years.

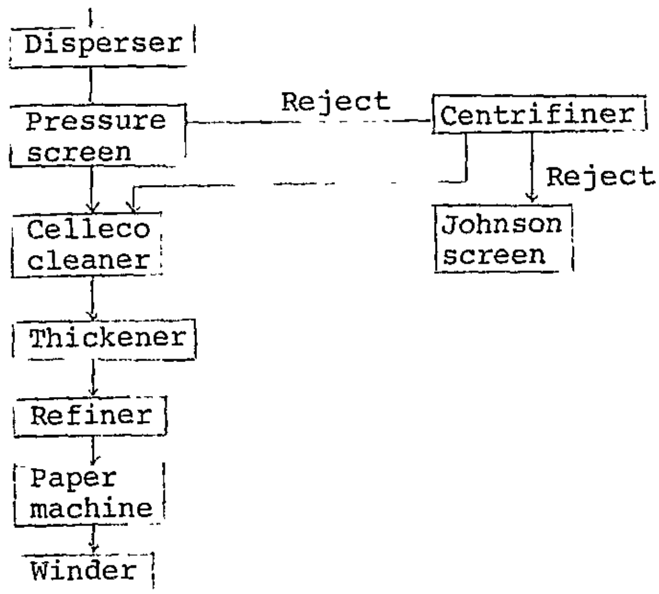
Introduction of up-to-date equipment adds strength to the activity of this company.

Most of raw materials they use are waste paper, out of which they make four kinds of product (150 - 160 t/d) such as liner board, shopping bag, paper, etc.

2. Manufacturing Process

(No. 2 Machine line)





3. Major Equipment

As No. 1 paper machine is out of operation at present, only No. 2 paper machine line is shown below.

(1) Stock preparation

Process	Major device	
Repulping	Pulper	3 units
Separating and screening	High density cleaner	1 set
	Double separator	1 set
	Disperser	1 set
	Closed pressure screen	1 set
	Liquid cyclone	1 set
Thickener	Cylinder Filter	1 set
Beating and Refining	Refiner	1 set

(2) Paper Machine

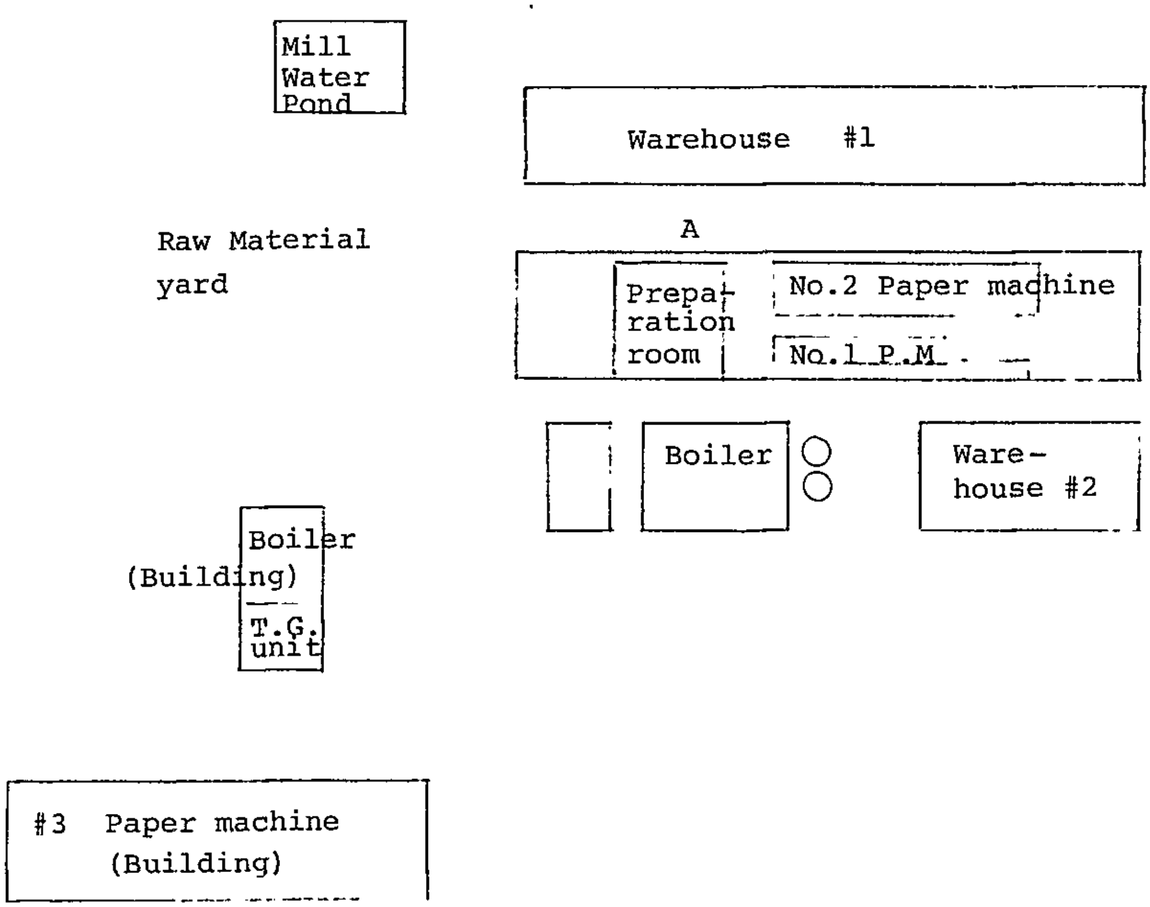
72" 4,160 m/m Fourdinier Multidryer

Major device	Type
Flow box	Closed type (double slice)
Press	Hi Nip Press
Dryer	4 groups, 38 cylinders
Hood	Open hood
Hot air blow	P.V. Roll
Expander	Clupak
Surface size ink	Size Press
Winder	2-drum type

(3) Boiler

Boiler No.	No. 1	No. 2	No. 3
Pressure	8 kg/cm^2	8 kg/cm^2	8 kg/cm^2
Amount of steam generated	9,000 kg/h	10,000 kg/h	10,000 kg/h
Fuel	Heavy oil	Heavy oil	Heavy oil

(4) Layout


Mill
Water
Pond
Warehouse #1
Raw Material
yard
A
Prepa-
ration
room
No.2 Paper machine
No.1 P.M.
Boiler
Ware-
house #2
Boiler
(Building)
T.G.
unit
#3 Paper machine
(Building)

4. State of Energy Management

The factory manager, who studied management science in the United States, is credited with numerical management. He keeps the day's record of production by product, as well as used amounts of electricity and fuel, and every consumption rate. Average energy consumption rates of the past are available, too. But he has no target set for energy conservation.

Executive communicate with each other in regular meetings, but no instruction is given to the workers. For a modern factory, machines are left dirty in the back, indicating that they are not adequately checked up.

They need to be careful enough not to tread underfoot scrap paper that can be recycled. Employees need to be given instruction as to what causes quality trouble.

None of the factories subject to our diagnosis, except this one, were found to be so careful as to give instructions to employees, such as the big "safety first" sign that this factory puts on the hood of the paper machine.

5. State of Fuel Consumption

Three heavy oil-burning boilers, in parallel running operation, are started or stopped according to steam pressure.

The consumption of fuel in each of the boilers is as shown below:

No. 1	7,410 liters/d
No. 2	8,840 liters/d

No. 3	9,720 liters/d
Total	25,970 liters/d

Steam generated is used in the paper machine. Use is also found for flash steam and provision is made for the recovery of some 60% condensate.

The absence of a feed water gauge compels us to make an estimate. Our calculations of thermal efficiency work out, as set out below, at about 80 - 85%.

The fuel consumption rate, though varying with the product, was found on our examination to be about 170 liters/t.

Heat Balance for No. 1 Boiler

Input (10^3 kcal/h, %)			Output (10^3 kcal/h, %)		
Combustion heat of fuel	3,102.1	99.5	Heat of steam	2,672.5	85.7
Sensible heat of fuel	15.2	0.5	Heat loss in exhaust gas	284.3	9.1
			Heat loss in blow water	4.6	0.2
			Heat release from boiler body	155.9	5.0
Total	3,117.3	100	Total	3,117.3	100

Notes:

1) Data given for determination of the heat balance -

Type of fuel - Fuel oil

Consumption of fuel (F) - 322 kg/h

Heat contents (low level) (Hl) - 9,634 kcal/kg

Specific heat of fuel (C_P) - 0.45 kcal/kg °C

Temperature of fuel (T_F) - 135 °C

Reference temperature (To) - 30°C

Oxygen content in exhaust gas (%) (O_2) - 6.1%

Temperature of exhaust gas (T_G) - 210°C

Amount of blow water (B) - 50 kg/h

Temperature of blow water (T_B) - 176°C

Temperature of feed water (T_W) - 85°C

Steam pressure (P) - 8 kg/cm^2 G

2) Equations for calculating the heat balance -

Input

a. Heat of fuel combustion (Q_C)

$$Q_C = F \times Hl = 3{,}102.1 \times 10^3 \text{ kcal/h}$$

b. Sensible heat of fuel (Q_S)

$$Q_S = F \times C_P (T_F - To) = 15.2 \times 10^3 \text{ kcal/h}$$

Output

a. Heat loss in exhaust gas (Q_E)

Theoretical amount of air (Ao) $= \frac{0.85\ Hl}{1{,}000} + 2.0$

$= 10.19\ Nm^3/kg$

Theoretical amount of exhaust gas (Go)

$= \frac{1.11\ Hl}{1{,}000} = 10.69\ Nm^3/kg$

Air ratio (m) $= \frac{21}{21 - O_2} = 1.41$

Actual amount of exhaust gas (G) = Go + Ao (m - 1)

$= 14.86\ Nm^3/kg$

$$Q_E = F \times G \times 0.33 (T_G - To) = 284.3 \times 10^3 \text{ kcal/h}$$

b. Heat loss in blow water (Q_B)

$Q_B = B \times (T_B - T_W) = 4.6 \times 10^3$ kcal/h

c. Heat release from boiler body (Q_R) .... Given as 5% of input,

$Q_R = (Q_C + Q_S) \times 0.05 = 155.9 \times 10^3$ kcal/h

d. Heat of steam (Q_V)

$Q_V = Q_C + Q_S - Q_E - Q_B - Q_R = 2,672.5 \times 10^3$ kcal/h.

e. Amount of steam evaporation (S)

Steam enthalpy (E_S) = 661.93 kcal/kg

Feed water enthalpy (E_F) = 85 kcal/kg

$S = Q_V \div (E_S - E_F) = 4,632$ kg/h

Heat Balance for No. 2 Boiler

Input (10^3 kcal/h, %)			Output (10^3 kcal/h, %)		
Combustion heat of fuel	3,400.8	99.5	Heat of steam	2,821.7	82.6
Sensible heat of fuel	16.7	0.5	Heat loss in exhaust gas	420.3	12.3
			Heat loss in blow water	4.6	0.1
			Heat release from boiler body	170.9	5.0
Total	3,417.5	100	Total	3,417.5	100

Notes:

1) Data and Equations of Heat Balance

Input

Consumption of fuel (F) - 353 kg/h

Oxygen content in exhaust gas (%) (O_2) - 8.8%

Temperature of exhaust gas (T_G) - 230°C

Other data are the same with No. 1 boiler.

Estimated amount of evaporation - 4,891 kg/h

Heat Balance for No.3 Boiler

Input (10^3 kcal/h, %)			Output (10^3 kcal/h, %)		
Combustion heat of fuel	3,738.0	99.5	Heat of steam	3,173.0	84.5
Sensible heat of fuel	18.3	0.5	Heat loss in exhaust gas	390.9	10.4
			Heat loss in blow water	4.6	0.1
			Heat release from boiler body	187.8	5.0
Total	3,756.3	100	Total	3,756.3	100

Notes:

1) Data and Equations of Heat Balance

Consumption of fuel (F) - 388 kg/h

Oxygen content in exhaust gas (%) (O_2) - 8%

Temperature of exhaust gas (T_G) - 210°C

Other data are the same with No. 1 boiler.

Estimated amount of evaporation - 5,500 kg/h

6. Problems of Heat Control and Solutions

(1) Stock Preparation Part

This is a system that satisfies all factors in the kind of equipment that makes something out of nothing but corrugated box waste paper.

We found much extraneous matter mixed in the products they turned out when we were there, because they said they were using waste paper of bad quality. We saw nothing offer any special problem.

We were asked questions about the power consumption rate in the preparation process. We found they had no statistical grip on the combination of machines and equipment which varies several ways. Cases of improvement reported to the Energy Conservation Center show that they use 86 kWh/t of waste paper on a capacity of 100 t/d.

(2) Press part

All equipment up to the making of wet sheet is being operated on an excellent system equipped with a Mitsubishi-Veloit converflow hi-nip press. In the dryer part are a single canvas clupak device for the first group and a hot air blow provision against dryer pockets, with a B/M meter fixed at the dryer end to maintain the computer control of paper weight and moisture.

This equipment is now in operation at the speed of 300 m/min, with scope left for up to 500 m/min.

Since the moisture of wet sheet going to the dryer registers 51% for 63.5 g/m^2, it can be said that the hi-nip press stands out in terms of dehydration performance.

(3) Dryer part

Dryers are in open hood style. As we felt a back flash of vapor at the dryer front of the third group, we tried to take measurements with the hygrometer we had with us. But the meter indicator swung too wildly (swinging between RH 51% and 81%) to measure either the upper or the lower line. This is presumably because air from the dryer side and vapor from between cylinders were not in a normal state of transposition. Installation of protectors in parts from the bottom end of the hood to the floor might help accelerate the flow of air at the bottom of the side and normalize the transposition of vapor from the cylinders.

The lower canvas of the third group was found to be low in temperature at the inlet of the group. This is probably because contact with the open air promotes heat radiation.

The most effective way might be to make hood closed. But provision should be make, for the time being, for hanging a curtain of polyethylene film that is transparent so that the interior can be seen and which readily opens at the time of a paper sheet break. This would achieve a saving of some 2% in the amount of steam used.

(4) Boiler

Steam flow meters installed appear to be out of use. They need due maintenace. No provision was found made for (1) feed water flow meter, (2) feed water thermometer, (3) fuel oil thermometer, (4) exhaust gas thermometer and (5) O_2 meter.

Although operators are not expected to take all the trouble with their boilers that are to be replaced next year, they might be advised to fix these meters and write down their readings in the diaries they keep now so that boiler control will be improved further. Changes in the temperature of exhaust gas, for instance, would make it possible for them to find dirt in the boiler tube soon.

The boiler performance is set out below:

Boiler No.	Rated amount of evaporation	Actual amount of evaporation	Load factor
No. 1	9,000 kg/h	4,632 kg/h	51.5%
No. 2	10,000 kg/h	4,891 kg/h	48.9%
No. 3	10,000 kg/h	5,500 kg/h	55.0%
Total	29,000 kg/h	15,023 kg/h	51.8%

Three boilers are being operated with a load factor of about 50%. This system of operation will result in heavy heat radiation, difficult air ratio control and bad efficiency. It might be advisable to let two of them operate, one in maximum running operation, and turn No. 1 boiler on and off in order to keep up the quantity of steam.

Air ratios, standing at 1.41, 1.72 and 1.62, should all be adjusted until they come down to approx. 1.3. This saves fuel by 2.2%.

Quality of Feed and Boiler Water. Raw water is for industrial use with 1,600 liters x 3 water softeners. Some soft water is being used in paper machines, in addition to boilers.

Records of water quality are set out below:

	Industrial water	Feed water	Boiler water
pH	7.7	8.3	10.82
Conductivity	800 μs/cm	450 μs/cm	9,130 μs/cm
Hardness	300 ppm	10 ppm	120 ppm
Phosphate	20 ppm	20 ppm	40 ppm
Iron	0.15ppm	0.15ppm	0.5 ppm
Chloride	30 ppm	10 ppm	160 ppm
Silica	20 ppm	7.5 ppm	50 ppm

We were told that the control target quantity of blow was set at an electric conductivity of boiler water of 5,000 μs/cm and that the electric conductivity of boiler water was measured once an hour. But the value was found to be as high as 9,130 μs/cm.

The quantity of blow, estimated at about 50 kg/h, needs to be increased. Since a desirable pH is 11-11.8, more alkali should be injected.

The oil service tank should be insulated, its surface made waterproof. A thermostat should be fixed to control the amount of steam. The feed water tank should also be insulated and the water level regulator should be repaired to prevent it from overflowing.

(5) Steam piping

Steam pipes in the paper machines are well insulated.

The main steam valve in each boiler needs to be insulated. This main steam valve, 6 inches in caliber, will cause, if not insulated, a heat loss of 2,810 kcal/h, three of them combining to lose 8,430 kcal/h.

Insulation of these valves would reduce the amount of heat radiation by about 75%. When calculated in terms of fuel, this works out as follows:

$$\frac{\text{Declining heat radiation}}{\text{Boiler efficiency x Heat contents of fuel}}$$

$$= \frac{8,430 \times 0.75}{0.85 \times 9,634} = 0.77 \text{ kg/h}$$

This means a saving of some 0.1% in fuel. Small as it may seem, it will be a saving of some 30,000 bahts when projected for a year.

No steam leakage. Well controlled.

Steam traps are generally in good condition.

7. State of Electric Power Consumption

Dryers, helpers and rewinders, powered by direct current motors, are well under thylister control Most transformers, equipped with condensers for use to improve the power factor, are turned on and off manually.

The factory was found clean on the front side, but there was a danger in the places surrounding the thylister transformers as they were littered with a lot of waste paper.

We were told that an in constant supply of electricity was a problem with them as they faced an eiqht-hour blackout once in two to three months and a short blackout almost every day.

(1) The principal data relating to power consumption are as follows:

Power comapny - PEA

Peak demand - 6,000 kW

Electric power used - 36,000,000 kWh/y

Load factor - 71.4%

Penalty fee - No penalty

Power factor - 83%

Transformers - 9,000 kVA (Total)

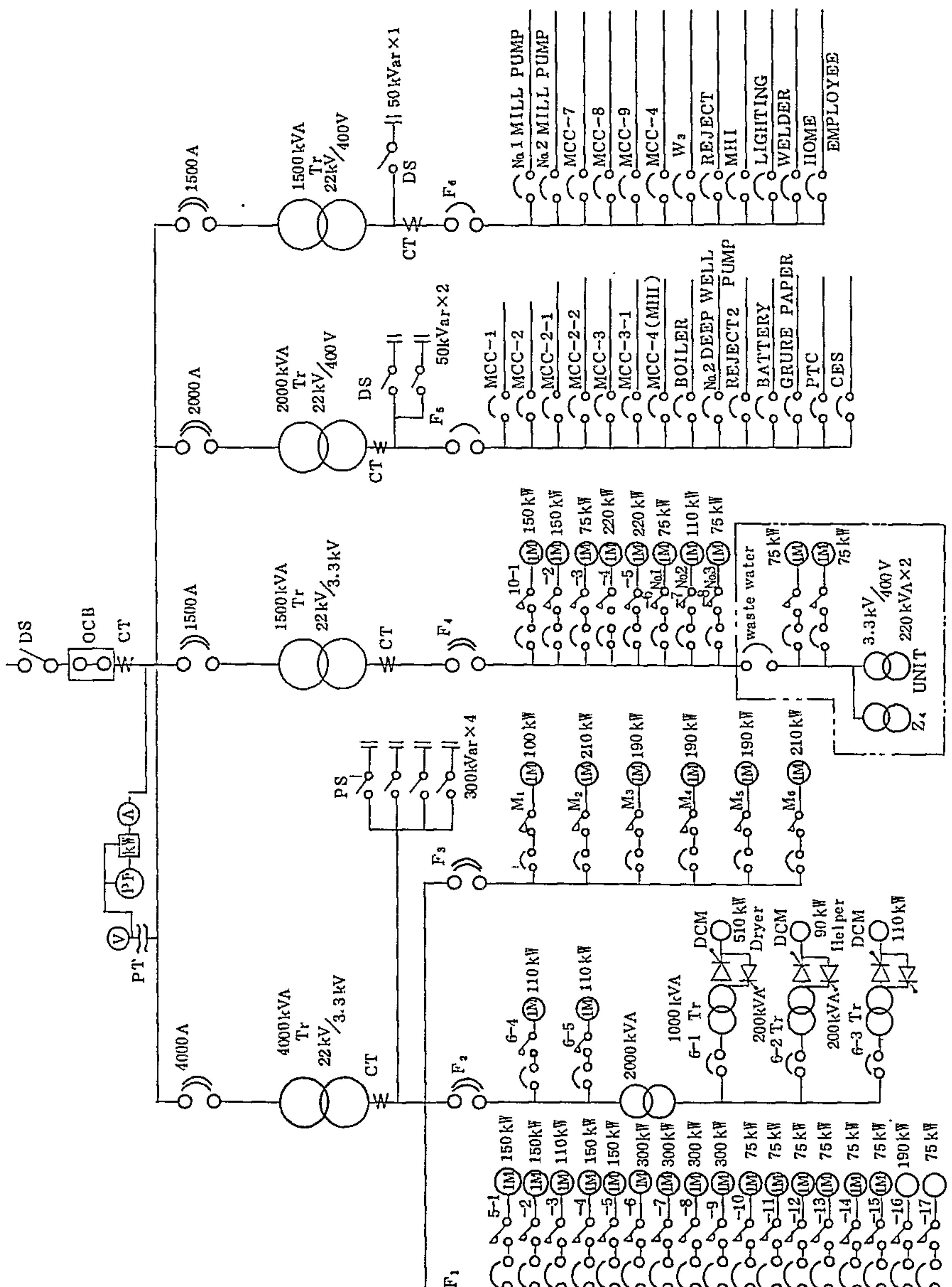
Power consumption rate - 685.7 kWh/t

Power consumption rates were under control on a product basis.

Grade No.	Power consumption rate		Remarks
	Standard	Actual	
4070	920	1150	70 g/m^2 for shopping bag
2105	650	640	105 g/m^2 at center
2127	610	620	127 g/m^2 at center

(2) One-line diagram

A one-line diagram was found well prepared with all indicators in good order at the receiving end.


DS
OCB
CT
PT
V
PF
kW
A
1500 A
2000 A
1500 A
4000 A
1500 kVA Tr 22kV/400V
2000 kVA Tr 22kV/400V
1500 kVA Tr 22kV/3.3kV
4000 kVA Tr 22kV/3.3kV
50 kVar×1
50kVar×2
300kVar×4
PS
F1
F2
F3
F4
F5
F6
№1 MILL PUMP
№2 MILL PUMP
MCC-7
MCC-8
MCC-9
MCC-4
W3
REJECT
MHI
LIGHTING
WELDER
HOME
EMPLOYEE
MCC-1
MCC-2
MCC-2-1
MCC-2-2
MCC-3
MCC-3-1
MCC-4 (MHI)
BOILER
№2 DEEP WELL PUMP
REJECT2
BATTERY
GRURE PAPER
PTC
CES
10-1 IM 150 kW
-2 IM 150 kW
-3 IM 75 kW
-4 IM 220 kW
-5 IM 220 kW
-6 No1 IM 75 kW
-7 No2 IM 110 kW
-8 No3 IM 75 kW
waste water
75 kW
75 kW
3.3kV/400V 220 kVA×2
UNIT
Z4
M1 IM 100 kW
M2 IM 210 kW
M3 IM 190 kW
M4 IM 190 kW
M5 IM 190 kW
M6 IM 210 kW
6-4 IM 110 kW
6-5 IM 110 kW
2000 kVA
6-1 1000 kVA Tr
DCM 510 kW Dryer
6-2 200kVA Tr
DCM 90 kW Helper
6-3 200kVA Tr
DCM 110 kW
5-1 IM 150 kW
-2 IM 150 kW
-3 IM 110 kW
-4 IM 150 kW
-5 IM 150 kW
-6 IM 300 kW
-7 IM 300 kW
-8 IM 300 kW
-9 IM 300 kW
-10 IM 75 kW
-11 IM 75 kW
-12 IM 75 kW
-13 IM 75 kW
-14 IM 75 kW
-15 IM 75 kW
-16 190 kW
-17 75 kW

8. Problems of Power Control and Solutions

(1) Peak demand and load factor

The factory manager says 36,000,000 kWh of electric power is used annually over 350 workdays.

The average power figures out at 4,285.7 kW with a load facotr of 71.4%.

(2) Transformer

Main transformer and condenser specifications are set out below:

Line No.	Transfomer capacity	Condenser capacity	Voltage	Remarks
F1 - F3	4,000 kVA	300 KVr x 4	22 kV/3.3 kV	Regularly 900 kVr needed
F4	1,500 kVA		22 kV/3.3 kV	
F5	2,000 kVA	50 kVr x 2	22 kV/400 V	
F6	1,500 kVA	50 kVr x 1	22 kV/400 V	

Loads on these transformers are set out below:

Line No.	Transformer capacity	Electric power	Apparent power
F1 - F3	4,000 kVA	2,800 + j1,195	3,044 kVA
F4	1,500 kVA	650 + j575	868 kVA
F5	2,000 kVA	1,070 + j798	1,335 kVA
F6	1,500 kVA	600 + j197	631 kVA
Total	9,000 kVA	5,120 + j2,765	5,819 kVA

Since the foregoing tabulations show that transformer capacity is too large, the load on the 1,500 kVA transformer in F4 line should be shifted on to the 4,000 kVA transformers in F1 - F3 lines, with more of the 900 kVr condensers installed so that apparent power will register 3,497 kVA. The load on the 1,500 kVA transformer in F6 line should be shifted on to the 2,000 kVA transformer in F5 line, with more of the 600 kVr condensers installed so that apparent power will register 1,716 kVA.

This reduction in the number of transformers will save electric power as set out below:

In F4 line, iron losses on the 1,500 kVA transformer will drop to 4,55 kW x 365 d/y x 24 h/d = 39,858 kWh/y and copper losses to 16 kW x $(\frac{868}{1,500})^2$ x (365 - 24) d/y x 24 h/d = 43,847 kWh/y, with copper losses on the 4,000 kVA transformer rising to

$$20 \text{ kW} \left\{ (\frac{3,497}{4,000})^2 - (\frac{3,044}{4,000})^2 \right\} \times (365 - 24) \text{ d/y} \times 24 \text{ h/d}$$

= 30,312 kWh/y, so the decrease of losses will be 39,858 + 43,847 - 30,312 = 53,393 kWh/y. Next, in F6 line, iron losses on the 1,500 kVA transformer will drop to 39,858 kWh/y and copper losses to 16 kW x

$$(\frac{631}{1,500})^2 \times (365 - 24) \text{ d/y} \times 24 \text{ h/d} = 23,172 \text{ kWh/y},$$

with copper losses on the 2,000 kVA transformer rising to $17 \text{ kW} \left\{ (\frac{1,716}{2,000})^2 - (\frac{1,335}{2,000})^2 \right\} \times (365 - 24) \text{ d/y} \times 24 \text{ h/d}$ = 40,431 kWh/y, so the decrease of losses wil be

39,858 + 23,172 - 40,431 = 22,599 kWh/y.

It follows from the above that operation without the use of two 1,500 kVA transformers means a saving of:

53,393 + 22,599 = 75,992 kWh/y

The cost of adding 1,500 kVr to the condensers is estimated at about 320,000 bahts.

The oil level gauge shows a considerable measure of foul transformer oil Since silica gel is also changing color, the transformer oil needs filtration.

(3) Operation of Motors

Motors are in operation as set out in the following table. The three motors mentioned below were found to be working at 50% or more below rated current.

Disposer	220 kW	39.6%
Disposer	220 kW	38.6%
No. 2 dryer well pump	110 kW	49.6%

Operation of Motors

Used for:	kW	Rated voltage	Rated current (A)	Load current (B)	(B)/(A) %
Pulper	150	AC 3,000 V	34.1 A	22.7 A	66.6
"	150	"	34.1	23.5	68.9
"	110	"	27	16.2	60

Centrifiner	150	"	34.1	Stop	-
"	150	"	34.1	22.1 A	64.8
Double Disc refiner	300	"	68	34.1	50.1
"	300	"	68	52.5	77.2
"	300	"	68	Stop	-
"	300	"	68	Stop	-
Vaccum pump	75	"	17.1	16.6 A	97.1
"	75	"	17.1	Stop	-
Back water pump	75	"	17.1	15.2 A	88.9
"	75	"	17.1	13.3 A	77.8
Refiner	75	"	17.1	11.9 A	69.6
Deep well pump	75	"	17.1	14	81.9
Centrifiner	190	"	43	Stop	-
Top-finer	75	"	17.1	10.1 A	59.1
Dryer	510	DC_{440} V	1,200	900	75
Helper	90	DC_{440} V	220	150	68.2
Rewinder	110	DC_{440} V	250	200	80
Hot air roll dryer device	110	$AC_{3,300}$ V	27	13.8	51.1
"	110	"	27	Stop	-
Vaccum pump	100	"	22.7	21.7	95.6 %
"	210	"	46	34.5	75%
"	190	"	43	26.4	61.4%
" press	190	"	43	23.7	55.1%
" wire	190	"	43	26.2	60.9%
" roll	210	"	46	39.1	85%

Pulp pump	150	"	34.1	stop	-
"	150	"	34.1	21.5 A	63%
"	75	"	17.1	17.1	100%
Disposer	220	"	50	19.8	39.6%
"	220	"	50	19.3	38.6%
No. 1 Deep well pump	75	"	17.1	Stop	-
No. 2 Deep well pump	110	"	25	12.4 A	49.6%
No. 3 Deep well pump	75	"	17.1	14.2	83%
Waste water pump	75	"	17.1	Stop	-
"	75	"	17.1	Stop	-

Some of the V-belt-driven pumps in the preparation part were found to be with only one of the three belts. The belts should be fixed up before they cause slips to incur power losses.

(4) Voltage

Secondary transformer voltage in F1 - F3 lines and in F4 line was found to be high at 3,200 V or higher. Since the rated motor voltage was 3,000 V, it might be advisable to change terminals on the secondary side of the transformer to lower voltage to 3,050 - 3,100 V. Terminals on the secondary side of the transformer in F5 line, which showed a secondary voltage of 375 - 380 V, should be changed to raise it to 385 - 390 V.

(5) Lighting

The fluorescent mercury lamps used for illumination were found to be off in the daytime. It seems that the daylight intake of the roof had better be made twice as large as it is now.

(6) Unbalanced Current

A 3% unbalance of current was found on the 390 V side of the 1,500 kVA transformer in F6 line. This unbalance offers no problem if it does not exceed 2%, but will cause an efficiency lowering of 1 - 2% if it registers 2% or higher. It is advisable to reconnect the monophase load for lights and welders, or to transpose the calbe.

9. Summary

In case the above-mentioned measures are taken, energy-saving effects will be expected as follows:

Measures	Potential energy saving	Rate (%)
A curtain fixed on the paper machine hood	210 kl/y	2
Improvement of the boiler air ratio	210 kl/y	2
Insulation of steam valves	7 kl/y	0.1
Subtotal	427 kl/y	4
Integration of transformers	75,992 kWh/y	0.2

Report No. 12: Paper

REPORT ON THE DIAGNOSIS

FOR

ENERGY CONSERVATION

- Thai Develop Paper Co., Ltd. -

January, 1983

Japan International Cooperation Agency

Contents

The Diagnosis for Energy Conservation

- Thai Develop Paper Co., Ltd. -

1. Outline of the Factory

Address : 247 Sukupiban Rd., T. Taiban A. Muang
Samutprakarn

Type of industry : Paper

Major products : Cardboard

Output : 30 t/d

No. of employees : 100

Annual energy consumption :

- Electric power : 3,613,200 kWh
- Fuel
  Fuel oil : 1402.56 kl

Interviewees : Montree, engineer, Sumboon, engineer, and Sanan, engineer

Date of diagnosis : Aug. 30 - 31, 1982

Diagnosers : A. Koizumi, K. Nakao, and K. Kurita

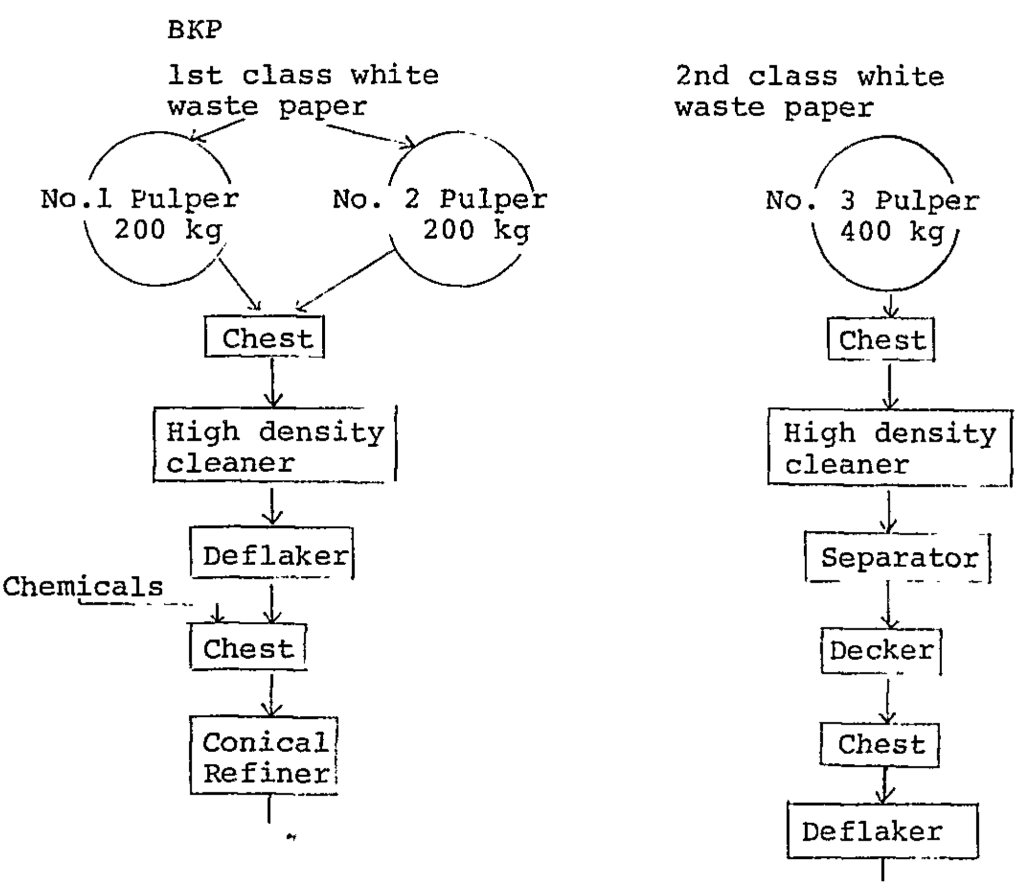
Thai Develop Paper's factory was put into operation eight years ago. When it comes to cardboard making, it is Thailand's third largest factory with a young and energetic staff as well as a laboratory.

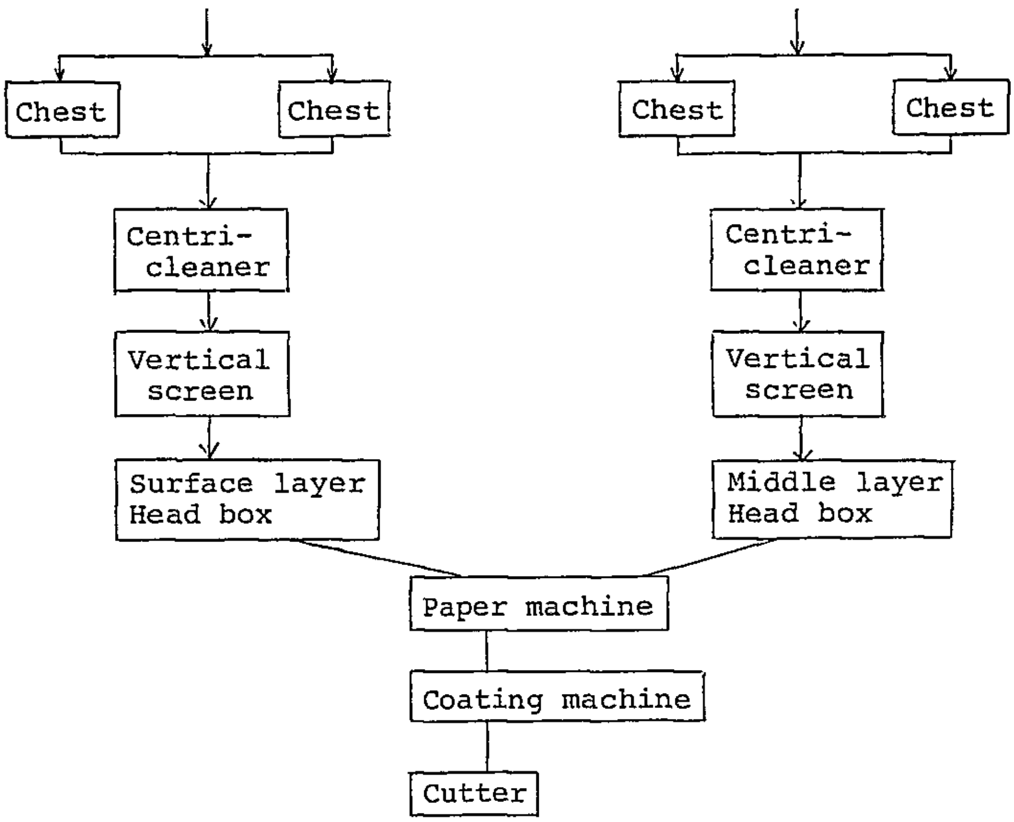
The factory is very active in bringing in anything new as is evidenced by the recent installation of a new lignite-fueled boiler and the order having been placed for an air preheater using waste heat recovered from the dryer's exhaust gas. Moreover, it is laid out conveniently for providing another production line; the construction of a backpressure turbine power plant is also under contemplation.

The factory people are studying paper making techniques under the guidance of a consultant from Europe.

Currently, the factory's output remains on the level of 30 tons a day due to the limited capacity of a coater/dryer. Although the stock preparation process has been successfully simplified, there are some problems yet to be solved in relation to the paper machine, the factory people said.

2. Manufacturing Process





3. Major Equipment

(1) Stock preparation

The stock preparation process is run with two lines of equipment; one is for 1st class waste paper and the other for 2nd class waste paper.

Process	Equipment for 1st class waste paper	Equipment for 2nd class waste paper
Repulping	Pulper (2)	Pulper (1)
Screening and separating	High density cleaner (1) Deflaker (1)	High density cleaner (2) Separator (1) Deflaker (1)

	Liquid cyclone (1) Closed cylinder screen (1)	Liquid cyclone (1) Closed cylinder screen (1)
Refining	Conical refiner (1)	
Thickener	Cylinder filter (1)	Cylinder filter (1)

(2) Paper and coating machines

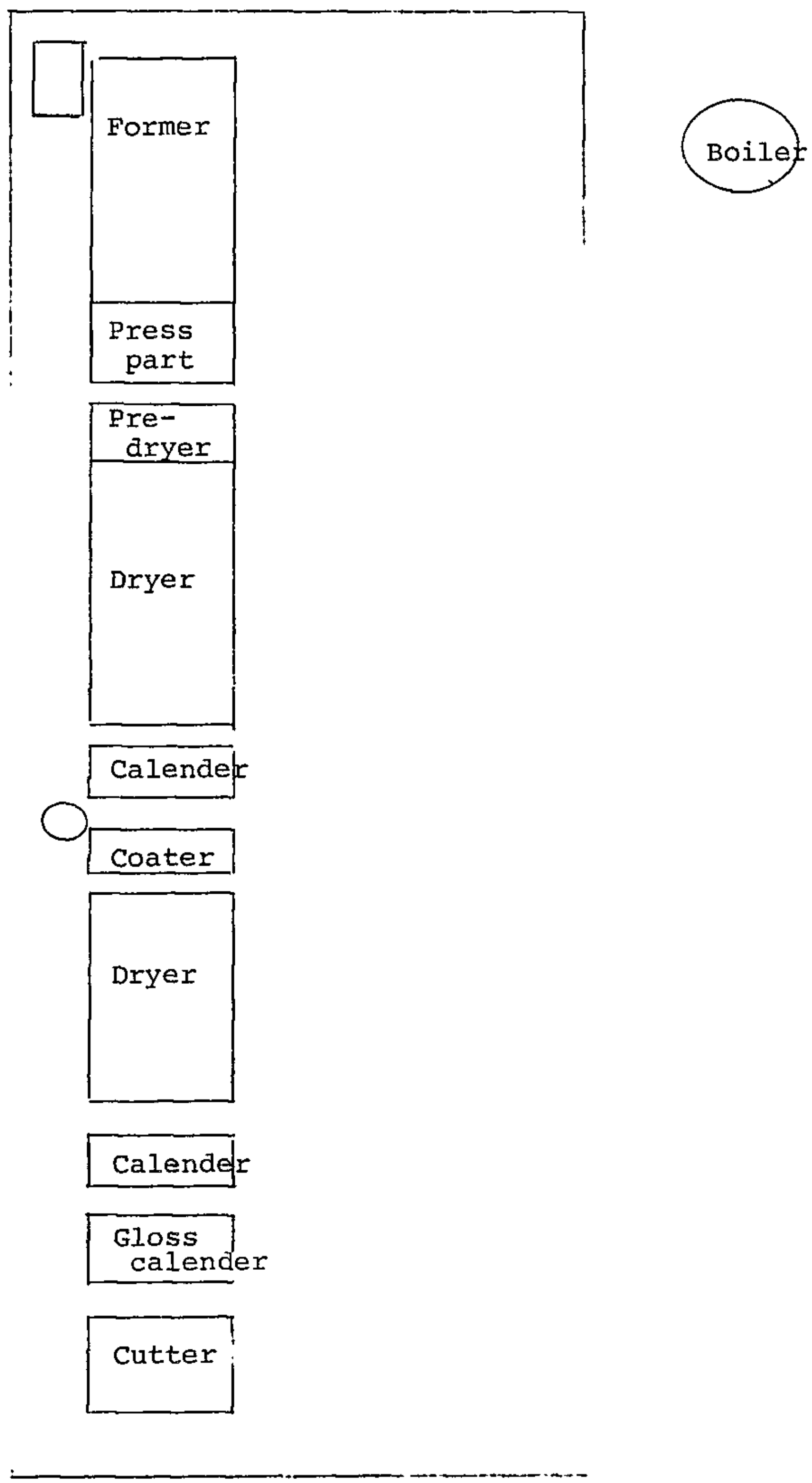
A 75" cylinder, multidryer paper machine is installed; this machine is capable of continuous operation with a coater and cutter.

Major devices	Type
Molder	Cylinder (5 units)
Press	Baby press (2 sets) Press (3 sets, inclusive of 2 suction presses)
Dryer	Predryer (2) Open-hood cylinder (14)
Calender	Roll (a set of five)
Coater	Roll coater Hot-air dryer After dryer (1 set)
Cutter	Single (1 set)

(3) Boiler

Evaporative capacity	9 t/h
Pressure	10 kgs/cm^2G
Fuel	Lignite with fuel oil as auxiliary

(4) Layout


Former
Press part
Pre-dryer
Dryer
Calender
Coater
Dryer
Calender
Gloss calender
Cutter
Boiler

4. State of Energy Management

The factory has a workforce of 130; these employees, all working on a full-time basis, are not given training. Emphasis is now placed on the repletion of equipment because workers at large lack a sense of responsibility, so we were told.

A list of motors is on hand; the load factor has formerly been measured. The newly installed boiler is fitted with both a fuel flowmeter and a feed water flowmeter. A control chart for quality control is also available, but it does not seem to have been in practical use.

5. State of Fuel Consumption

It is not so long since the lignite-burning boiler was brought into service in place of the former fuel oil-buring one. Though its rated capacity is 9 t/h, this boiler is now operated at the capacity of up to 4 t/h and still provided with fuel oil as an auxiliary fuel.

	Rated consumption	Measured consumption
Lignite	9.6 - 12 t/d	12 t/d
Fuel oil	1,800 - 0 liters/d	400 liters/d

Steam is used in the dryers for the paper machine and coater.

Shown below is the heat balance in the boiler.

Heat Balance in the Boiler

Input (10^3 kcal/h, %)			Output (10^3 kcal/h, %)		
Heat of lignite combustion	2,721.0	94.5	Heat of steam	1,914.7	66.5
Combustion heat of fuel oil	156.0	5.4	Heat loss in exhaust gas	292.4	10.2
Sensible heat of fuel oil	0.4	0.1	Heat loss in blow water	2.2	0.1
			Miscellaneous (Heat release from boiler body, and heat loss in ashes, etc.)	668.1	23.2
Total	2,877.4	100	Total	2,877.4	100

Notes:

1) Data given for determination of the heat balance -

Reference temperature (To) - 30°C

Type of fuel - Lignite (water content: 7%)

- Fuel oil

Temperature of fuel

Lignite - 30°C

Fuel oil - 90°C

Fuel consumption

Lignite - 500 kgs/h

Fuel oil - 16.1 kgs/h

Heat contents of fuel

(low level, Hl)

Lignite	-	5,442 kcal/kg
Fuel oil	-	9,692 kcal/kg
Oxygen content in exhaust gas (%)	-	8.9%
Temperature of exhaust gas	-	200°C
Steam pressure	-	7.5 kgs/cm^2G
Temperature of feed water	-	85°C
Amount of blow Water	-	25 kgs/h
Quantity of feed water	-	3,321.8 kgs/h

2) Equations for calculating the heat balance -

Input

a. Heat of fuel combustion (lignite)

500 kgs/h (consumption of fuel) x 5,442 kcal/kg (calorific value of fuel, Hl) = 2,721.0 x 10^3 kcal/h

b. Combustion heat of fuel (fuel oil)

16.1 kgs/h (consumption of fuel) x 9,692 kcal/kg (calorific value of fuel, Hl) = 156.0 x 10^3 kcal/h

c. Sensible heat of fuel oil

16.1 kgs/h (consumption of fuel) x 0.45 $kcal/kg^oC$ (specific heat of fuel) x [90°C (temperature of fuel) - 30°C (reference temperature)]

= 0.4 x 10^3 kcal/h

Output

a. Heat loss in exhaust gas

Flow rate of wet exhaust gas = 4,846 Nm^3/h

Flow rate of dry exhaust gas = 4,802.4 Nm^3/h

Moisture of exhaust gas = 43.6 Nm^3/h (35 kgs/h)

Heat loss in dry exhaust gas =

$4,802.4 \times 0.33 \times (200 - 30) = 269.4 \times 10^3$ kcal/h

Heat loss in moisture of exhaust gas =

$35 \times (686.8 - 30) = 23.0 \times 10^3$ kcal/h

Heat loss in wet exhaust gas = 292.4×10^3 kcal/h

b. Heat loss in blow water

Amount of blow water = 25 kgs/h

Temperature of blow water = 174°C

Heat loss in blow water =

$25 \times (174 - 85) = 2.2 \times 10^3$ kcal/h

c. Heat of steam

3,321.8 kgs/h (flow rate of feed water) x

[661.4 kcal/kg (enthalpy of steam) - 85 kcal/kg (enthalpy of feed water)]

$= 1,914.7 \times 10^3$ kcal/h

6. Problems in Heat Control and Potential Solutions

(1) Stock preparation part

The capacity of equipment in the stock preparation process is larger than that of the paper machine and coater. In that case, most of the paper mills usually base the operation of whole equipment on smaller capacity in spite of reduced efficiency because, from their point of view, otherwise they will experience an increased burden on labor as well as a lack of balance temporarily in the manufacturing processes. The factory under review, on the other hand, is running equipment for stock preparation on an on-and-off basis according to a production plan, which is shaped following its policy of eliminating energy losses due to lower efficiency in operation. Reflecting the management's active attitude, this practice is really worth praising.

Another point worthy of attention is that this factory uses a very small amount of water to make paper; its water consumption rate runs at 30 tons per ton of paper, which represents a high level of performance even from the world's standard. Consequently, temperatures are kept at 36 to 37°C in the head and flow boxes of the machine, contributting greatly to the retrenchment of steam in the dryer.

This is mainly because, as distinguished form other factories, the high density cleaner has a capacity enough to separate foreign matters and, therefore, the process of dilution and concentration can be omitted. Moreover, other down-to-earth energy-saving measures are taken - for instance, five of the fifteen chests are placed at rest and the remaining ten are running to meet work requirements.

(2) Press part

A. Sheet formation

The temperature inside a vat is kept at a high level of 36°C, indicating that the operation of the white water circulating system as well as the machine goes well along.

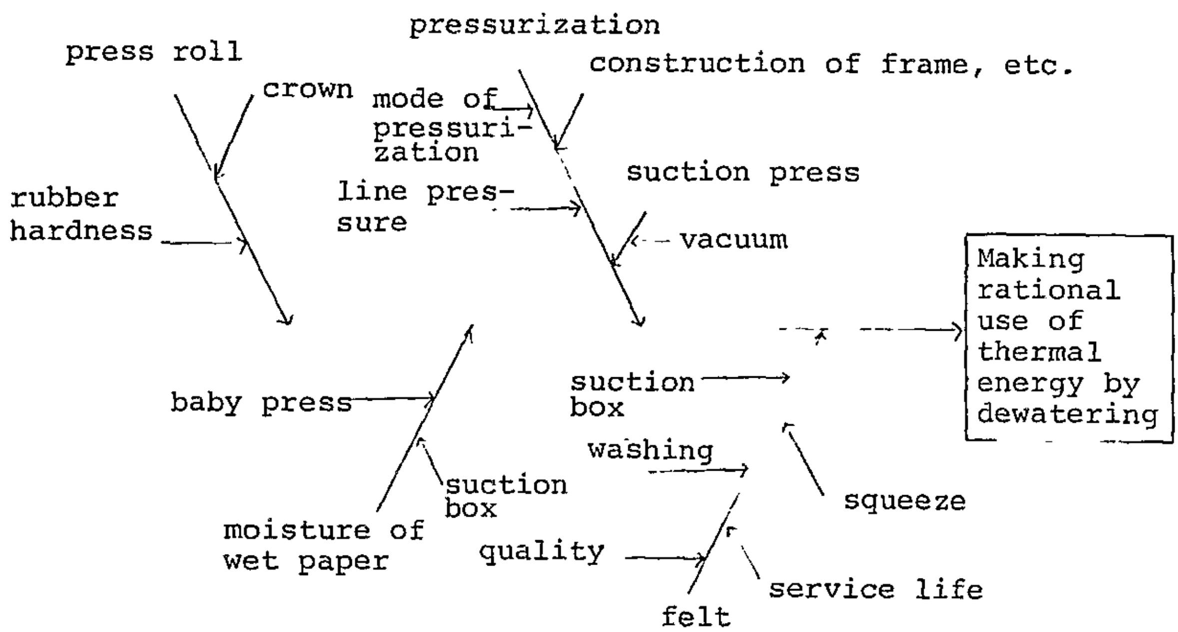
B. Press part

No data on moisture at the wet end was made available, nor was there a chance for the study mission to find the water content.

Laboratory researchers and the personnel in charge of paper making and equipment should work together to increase the dehydrating efficiency by checking up on the wet end moisture and carrying out pressurization test of press roll.

A 1 percent reduction moisture at the wet end could decrease the quantity of steam required in the dryer by 3 to 5 percent.

Factors contributing to a rise in the dehydrating efficiency at the press part, for your information, can be illustrated as follows:



Points to be considered are:

a. Press roll

The press roll's crown, when it is removed, should be checked to see if it is in shape as specified, and if not, it should be ground to make it in proper shape. A rubber roll should also be inspected to see if it has a proper hardness.

b. Pressurization

The construction, strength and other properties of a frame should be examined in advance to raise the roll's pressure level as high as possible.

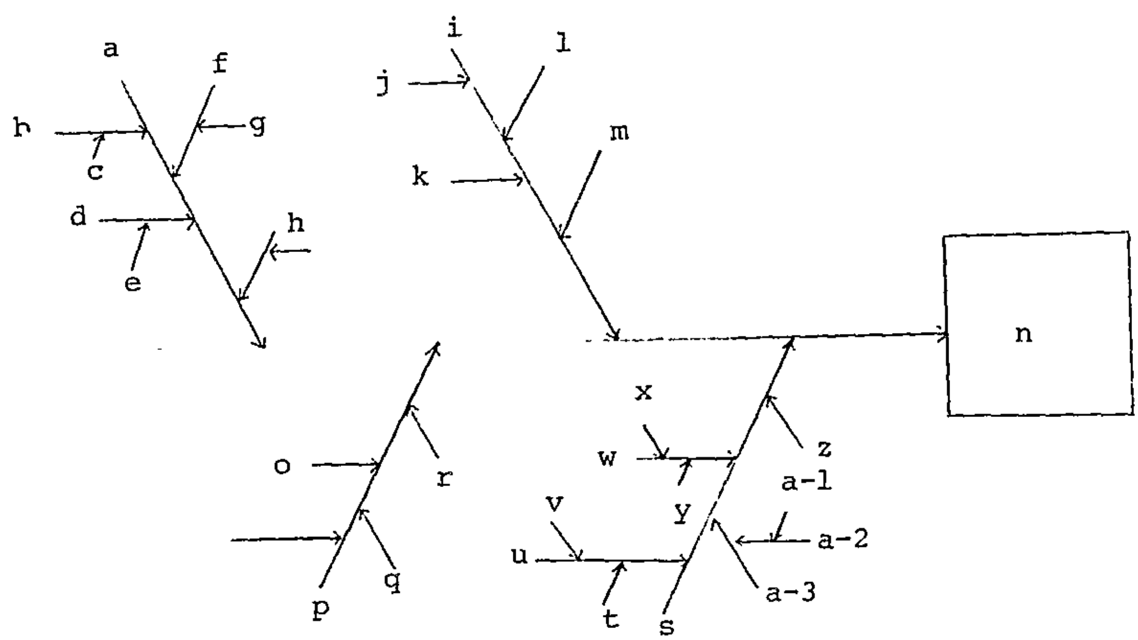
c. Something should be done to let the baby press and suction box function to the full so that the water content of wet paper can be reduced before it goes into the press.

d. A felt is compressed under the press's nip pressure, and the moment it is relieved from that pressure, it abruptly swells and absorbs water from wet paper. As such, the felt should be highly elastic, easy to absorb water, and fine in texture. In addition, the washing shower and suction box should be allowed to function satisfactorily.

Make sampling of wet paper at four to five spots in the cross direction to see how much its moisture varies from spot to spot, and you will be able to make an easy analysis of the unusually high value of moisture, if any.

(3) Dryer part

This is a part where the largest quantity of steam is consumed and, therefore, there are many factors involved that could trim energy consumption. These factors can be expressed in the following graphical form:



a. dryer cylinder; b. surface cleaners; c. doctor; d. condensate brush; e. siphon; f. steam; g. pressure of steam (temperature); h. no. of units; i. canvas; j. air permeability; k. canvas dryer; l. tension; m. hot air blow roll; n. making rational use of thermal energy in the dryer; o. use of flash steam; p. drainage system; q. trap; r. heat insulation; s. ventilation; t. closed hood; u. hood; v. open hood; w. draft; x. natural draft; y. forced draft; z. waste heat recovery; a-1. unevenness of air stream; a-2. unevenness in drying; a-3. construction of hood

A. Dryer cylinder

The thickness of a condensate film in the dryer should be taken into account as one of the important factors affecting energy conservation. A siphon is designed to make the condensate film always thin. It is necessary to check the siphon at regular intervals to see if a clearance in its tip and inner wall is as specified. The clearance varies greatly with the type of siphon, so it is better to regulate it in light of various catalogs issued by manufacturers.

B. Canvas

A canvas comes into contact with wet paper, and holds and releases its vapor in an open space between cylinders. So it is necessary to keep the canvas clean and maintain its temperature at a high level.

C. Ventilation

Better ventilation of the so-called dryer pocket - a section inside the dryer surrounded by a cylinder, canvas and sheets of paper - will result in an increase in the drying efficiency. In this respect, the hot air blow roll is an effective device as it blows a hot air over the canvas roll to accelerate the drying of the canvas and improve the ventilation of the dryer pocket.

The dryer hood was an open one and well-ventilated, but it seems to have taken in too much air from outside due to its excessively good draft. Temperatures at various spots of the dryer's front part were:

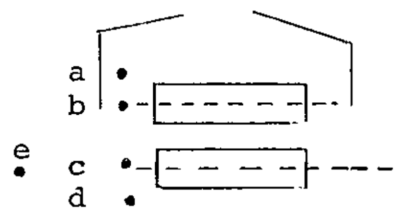
42°C at the point a

38°C at the point b

35°C at the point c

32°C at the point d

30°C at the point e



A measure to be taken immediately is to hang a curtain from the tip of the hood so that the air can be kept from coming in excessively and the ventilation of the dryer can be speeded up. Then, a drop in the temperature can also be prevented.

A pressure gauge should be fitted at the front side of the dryer as well so that the pressure level of steam to be blown in can be controlled in light of the dryness of paper. Furthermore, a valve handle will have to be extended, by means of a universal joint, to somewhere around the calender in order to allow an easier opening and closing of the valve.

These measures are expected to afford a saving of about 3 percent in steam.

D. Water coating at the calender

From the technical as well as economical point of view, it is not a good idea to coat paper in water in an attempt to prevent it from curling in the calender.

Some alternatives are available, which should be carried out on a case-by-case basis. These include:

a. To change the composition of fibers in surface and back layers of paper;

b. To differentiate surface temperatures of the upper and lower dryers to correct curled paper - that is to say, to accelerate the shrinkage of a surface layer, raise the surface temperature of the upper dryer, and to speed up the drying of a back layer, elevate the surface temperature of the lower dryer; and

c. To vary the amount of steam to be fed into the fore and rear dryer so as to change the period of constant-rate and reduced-rate drying.

Judging by the results we obtained, it seems that both edges of paper tend to hang down. This may be primarily because of excessively high surface temperatures of the upper dryer resulting in the great shrinkage of the surface layer. Or it may be attributable to the freeness of fibers in the surface layer being relatively lower than that of fibers in the back layer.

Curling of a sheet of paper occurs this way: if one side of the sheet is dried earlier than the others, this side will shrink first, and then the whole sheet will curl to this side. The problem is, however, that curling occurs sometimes in the initial stage of drying and sometimes in the final stage, depending on what equipment are provided and what quality of paper is to be made. So there is no choice but to conduct experiments to find the best way of curling prevention fitted for practical use.

At any event, water coating at the dry end should be discontinued by all means as it will increase a burden on the coater suffering from a shortage of dryer capacity.

The discontinuance of water coating will result in some reduction in steam in the color coater. All in all, a saving of about 2 percent in steam can be achieved.

E. Color coating

The temperature of color was found to be rather low at 31°C. Though it may be due to a drop in the temperature of paper resulting from water coating as mentioned above, the temperature of color should preferably be kept at a much higher level. Then, a burden on the coater dryer will be alleviated and the steam consumption rate will be improved.

(4) Boiler

It is a lignite-burning, vertical water tube boiler provided with fire doors on both sides of the lower part as well as with a chain grate stoker which allows to feed fuel and take out ashes from the right and reverse directions alike.

This boiler has been installed only recently and has been on a trial run for three days when we visited this factory. The rated and working levels of its evaporative capacity and steam pressure are as shown below.

	Rated level	Working level
Evaporative capacity	9 t/h	4 t/h
Steam pressure	10 kgs/cm^2G	7 - 7.5 kgs/cm^2G
Fuel	Burning lignite together with fuel oil	

The boiler is fitted with a feed water flowmeter; operational data and records of water quality analysis are available, if partially. These should desirably be utilized to run the boiler efficiently. For example, one of the most important indicators, the amount of feed water/(the amount of lignite x $\frac{5.4}{9.7}$ + the amount of fuel oil), can be reckoned to make a rough standard for the boiler's performance.

According to the heat balance, the boiler's efficiency stands at 66.5 percent, which may be due to the load factor showing a rather low level of 37 percent as well as to heat loss in lignite ashes. The boiler body is insulated well, but part of the downcomer pipe is not insulated, which should be given complete insulation. Moreover, ashes are found to have contained some pieces of live lignite, which should be burnt up when taken out. A thermometer should be provided to measure and control the temperature of exhaust gases, though this temperature is kept at a proper level of 200°C. The air ratio runs at a rather high level of 1.74. To bring it down, it is advisable to throttle the quantity of exhaust gases slowly to such an extent that no black smoke will be given off.

Shown below are data on the quality of feed water and boiler water.

	Feed water	Boiler water
pH	7.9	8.72
Electric conductivity	1,040 μS/cm	15,940 μS/cm

The pH of boiler water is too low; it should be raised to around 11. Also, its electric conductivity of 15,940 μS/cm is too high. It should be brought down to 6,000 μS/cm or below by increasing the amount of blow water as well as by having another look at the quality of feed water.

Water is drawn from a well, filtered through sand, and passed through a water softening plant (500 liters of resin) to provide feed water. Feed water is high in hardness according to a report on water quality. This may be because of the degradation of resin. The water softening plant, we were told, has never been inspected; it should be kept in good order by taking out resin periodically to wash and clean it and supply it, if necessary. Make sure, in this regard, to make back washing in treated water.

A drain is recovered for use as part of feed water and the drain recovery rate stands at 70 percent, the factory people said. And the temperature of feed water is 85°C. A feed water tank looks as if releasing a large amount of heat; the surface temperature of the tank is kept at 90°C. Based on an analytical table of feed water quality, the drain recovery rate is estimated at 60 percent.

The drain recovered is found to have overflown of the feed water tank. An attempt should be made to increasing the amount of drain recovered and adjusting its water level by controlling the flow rate of soft water. It is also necessary to give the tank better insulation so that heat loss can be reduced.

(5) Steam pipes

A total of three valves - a main steam valve and two steam header valves - and part of the downcast pipe for the boiler are left uncovered; they must be insulated.

Poor insulation of pipes around the paper machine attracted our attention. They must be fixed right away. A newly installed pipeline is insulated well.

Steam pressure at the dryer part runs at 4.8 kgs/cm^2G. Although flash steam is used in the first dryer, its pressure level is not made clear. A pressure gauge should be placed in good repair.

Flash stages are provided in insufficient numbers. It is advisable to increase stages to three to four and bring a drain in the final stage back to the boiler's feed water tank. There was almost no steam leakage observed.

If the three 6-inch valves are insulated, then heat loss will be reduced by the following amount:

	Heat loss		Heat loss reduced by:
	Without insulation	With insulation	
Three 6-inch valves	8,737 kcal/h	259 kcal/h	8,478 kcal/h

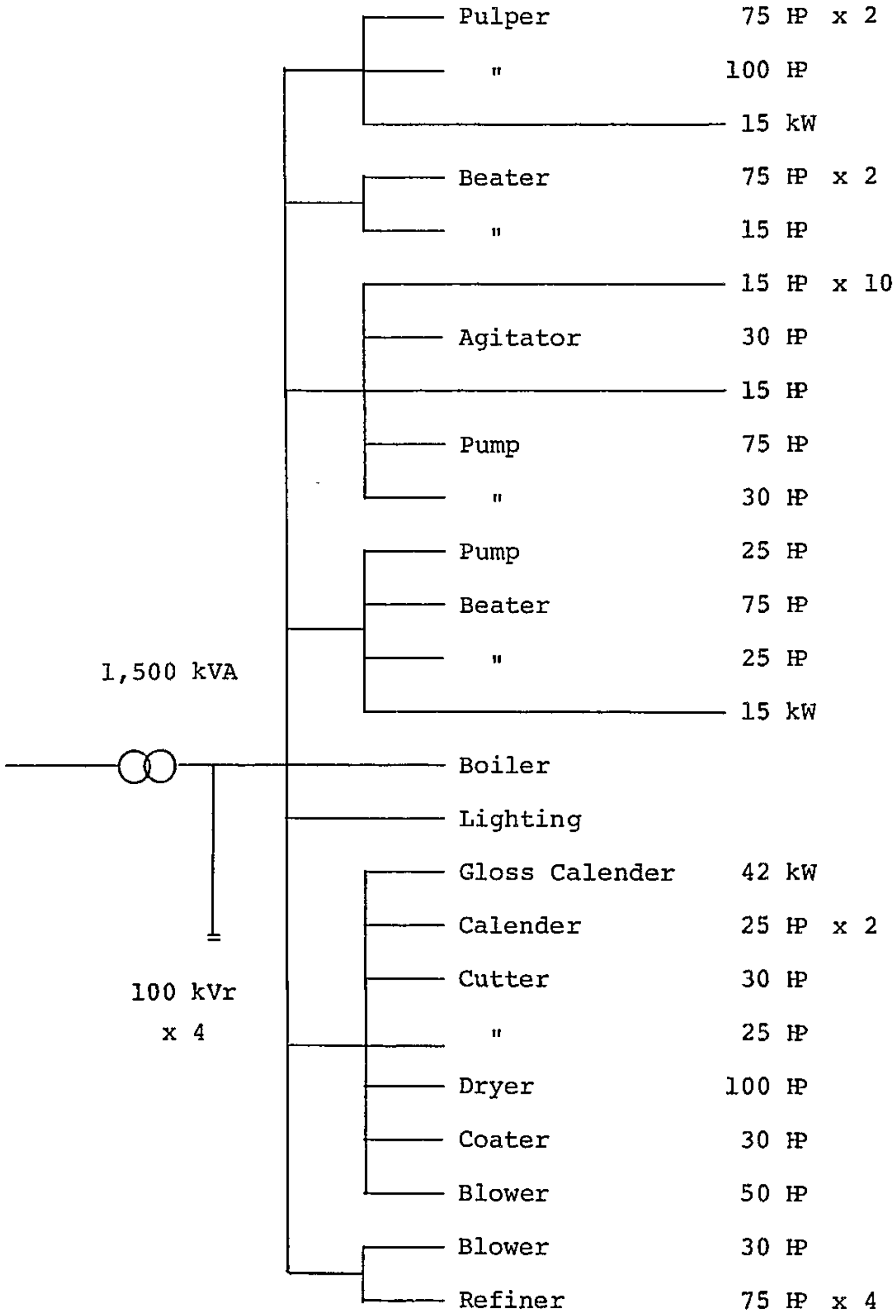
This reduction of 8,478 kcal/h in heat loss is equivalent to a saving of 14.7 kgs/h or 0.4 percent in steam as compared with the quantity evaporated.

7. State of Electric Power Consumption

(1) The principal data relating to power consumption are as follows:

Power company	-	MEA
Peak demand	-	740 kW
Power consumption	-	495 kW (average)
Load factor	-	66.9%
Penalty	-	Penalty imposed
Power factor	-	93 to 98%
Transformers	-	1,500 kVA, 22 kV/400 V

(2) One-line diagram



8. Problems in Electric Power Control and Potential Solutions

(1) Load factor

Given the peak demand of 740 kW and the average power consumption for June of 495 kW, the load factor is calculated at 66.9 percent. This level is low in view of the transformer's capacity of 1,500 kVA; the load amounts to no more than 779 kVA (740/0.95 at its peak.)

(2) Power factor

The power factor runs at a high level of 93 to 98 percent because a power-factor improvement is made by connecting a condenser with the 400 V side of an receiving panel. However, the condenser is not used properly as it is turned on and off manually by a worker due to a relay out of order. As a consequence, the maximum value of reactive power for June reached a record high of 650 kVr; the factory paid a penalty for an excess over 63 percent of the peak demand of 740 kW. The relay should be repaired immediately so that the condenser is turned on and off automatically. Then, the factory will have to pay no more penalty and, in turn, will be able to achieve an annual saving of 33,120 bahts.

(3) Voltage

The receiving panel is provided with a voltmeter that indicates the transformer's secondary voltage. The voltmeter was found to have read 375 to 380 V.

In some cases, it is 50 to 70 meters distant from the receiving and secondary panels to motors. Taking into account a voltage drop in a cable covering this distance, the secondary voltage at the receiving panel should better be raised to 385 to 390 V. To do so, the voltage must be recorded every hour, and if it continues to be lower than 380 V for a long time, a tap for the transformer should better be changed. If the motor's voltage is higher or lower than the rated level, its efficiency will decrease whereas its loss will increase.

(4) Operation of motors

The desirable load level is 60 percent or more of the rated power of the motor. If this is lower than 60 percent, the motor's power factor will get adversely affected, requiring more electric current than the load level and resulting in greater loss in the transformer and cable.

The table below shows how motors are operated.

<u>Operation of Motors</u>

Used for:	Output HP	Rated Ⓐ Current	Load Current Ⓑ		Ⓑ/Ⓐ %	Power factor %
			PM 2.15	PM 3.15		
Pulper	75	380V 102A	A	35A	34.3	20
"	75	" 102				
"	100	" 136		53.1	39	71
Beater	75	" 102	34.1		33.4	20
"	75	" 102				

Agitator	30	"	43	23.4		54.4	69
Pump	75	"	102				
"	30	"	43	22.3		51.9	65
"	25x2	"	34				
Beater	75	"	115	24.7	24.6	21.5	10
Water pump	25	"	34				
Refiner	75	"	115	36.9		32.1	20
"	75	"	104				
"	75	"	103				
"	75	"	102	75	77.7	76.2	80
Blower	30	"	43	39.2	44.4	103.3	86
"	50	"	68	29.1	28.9	42.8	50
Coater	30	"	43				
Dryer (paper)	100	"	136	110.0	110.0	80.9	84
Cutter	25	"	34				
"	30	"	43	15.2	15.6	36.3	20
Calender	25		34				
"	25		34		9.7	28.5	10
Gloss Calender	42kW		77	29.0	29.5	38.3	10

Motors, excluding those 75, 30, and 100 HP units for the refiner, blower, and dryer respectively, are given a small load. If the pulper, beater, refiner and cutter are run by each motor and the load factors for these motors are increased, then the power factor will be improved and the resistance loss in the transformer and wiring will be reduced. Though it is an already established practice at this factory, equipment, if operated for many hours at small load, should better be run for a shorter time in such a manner that a load can be raised to about 80 percent of the rated output. Supposing that two of the pulpers and beaters are reduced to one to be operated for three hours a day, the following amount of electric energy can be saved.

The no-load loss of the pulper is calculated at: $\sqrt{3}$ x 380 V x 45 A x 0.1 = 3 kW. An annual saving of electric power for this unit will amount to: 3 kW x 3 h/d x 341 d/y = 3,069 kWh/y. Likewise, the beater's no-load loss is reckoned at: $\sqrt{3}$ x 380 V x 38 A x 0.1 = 2.5 kW. And an yearly saving of electric power that can be achieved for the beater will amount to: 2.5 kW x 3 h/d x 341 d/y = 2,558 kWh/y. Taken together, electric power can be saved by 5,627 kWh/y.

(5) Lighting

It is better to replace fluorescent lights, which are currently installed for lighting of the whole factory, by mercury lamps. This replacement, however, costs very much as it is necessary to change apparatuses and provide ballast stabilizers. Therefore, it is advised to replace the existing daylight, fluorescent lights by cool white ones. In that case, the luminous flux will increase by 10 percent and hence a 10 percent reduction in the number of lamps.

Supposing that these cool white fluorescent lamps are kept on for twelve hours a day, electric power can be saved by: 40 w x 2 x 34 lamps x 0.1 x 12 h/d x 341 d/y = 1,113 kWh/y.

9. Summary

The above remedial measures, if actually taken, will bring about energy-saving effects as shown below:

The steam saving quantity and rate:

- By a 1% moisture reduction at the wet end in the press part	- 93 kl/y(fuel oil)	4%
- Through adjustment of a drain film in the dryer cylinder, prevention of the canvas getting dirty, better control of temperatures, and improved ventilation in the hood	- 70 kl/y(fuel oil)	3%
- As a result of the discontinuance of water coating	- 47 kl/y(fuel oil)	2%
- By perfect insulation of the valves	- 9 kl/y(fuel oil)	0.4%
Total:	219 kl/y(fuel oil)	9.4%

The power saving volume and rate:

- By improving the operation of small-load equipment	-	5,627 kWh/y	0.16%
- By replacement of daylight fluorecent lamps by cool white ones	-	1,113 kWh/y	0.03%
Total:		6,740 kWh/y	0.19%

Report No. 13: Paper

REPORT ON THE DIAGNOSIS

FOR

ENERGY CONSERVATION

- Cardboard (Thailand) Co., Ltd. -

January, 1983

Japan International Cooperation Agency

Contents

The Diagnosis for Energy Conservation

- Cardboard (Thailand) Co., Ltd. -

1. Outline of the Factory

Address : 1 Moo 2 Petchkrasem Rd., T. Raiking, A. Sampran, Nakornprotomp

Capital : 25 million Bahts

Type of industry : Paper

Major products : Brown board, white board

Annual output : 10,800 t

No. of employees : 189

Annual energy consumption :

- Electric power : 6,821,628 kWh
- Fuel
  - Fuel oil : 2,016 kl

Date of diagnosis : Sep. 13 - 14, 1982

Diagnosers : A. Koizumi, K. Nakao, and K. Kurita

Cardboard (Thailand) Company's factory is currently producing 36 tons of board a day from waste paper with the following two paper machines:

No. 1 machine - 66" wide, 16 t/d

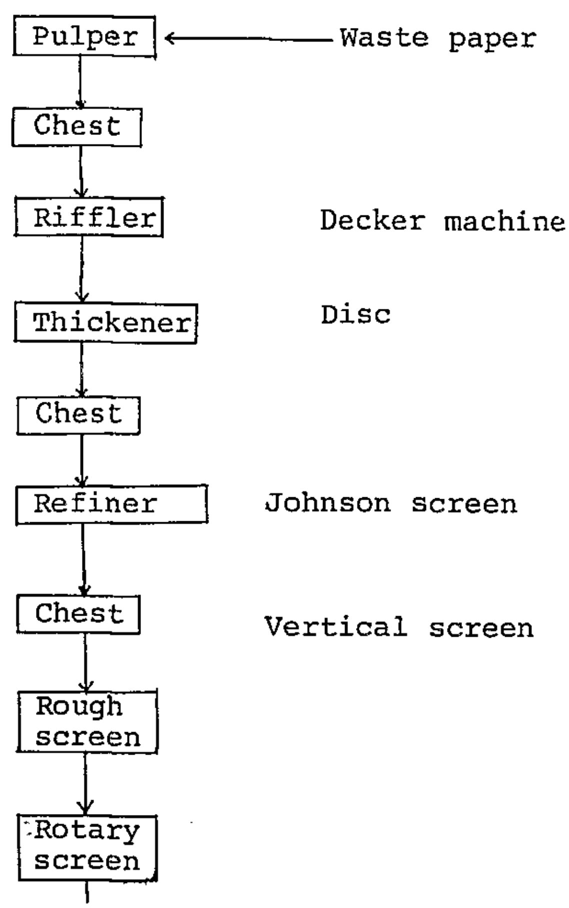
No. 2 machine - 72" wide, 20 t/d

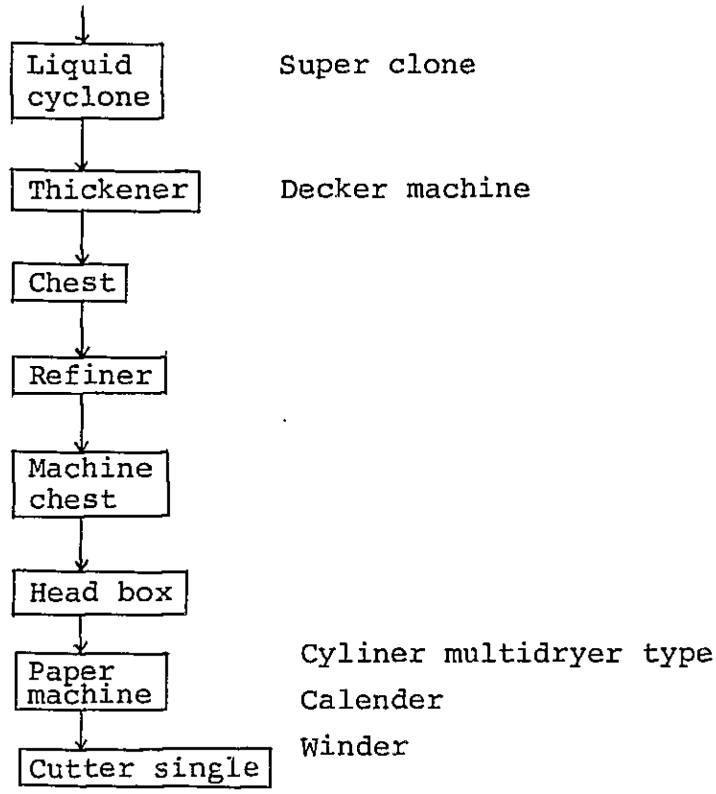
The factory is tended with great care. The No. 2 paper machine was placed at rest for repair. Taking this opportunity, workers were painting frames, pipes and other parts.

What attracted our particular attention is that an insulated steam pipe on the back side of a dryer was covered with a used felt to afford better insulation, which was done on the initiative of an employee. All this reflects the factory manager's positive attitude toward improvement of business operations.

Being a middle-scale concern in Thailand's paper making industry, the firm is highly motivated to better factory management as is evidenced by the fact, for example, that engineers are sent out to a variety of training courses given by the TPA in an effort to raise their technical level.

2. Manufacturing Process





3. Major Equipment

(1) Stock preparation

Process	Type of equipment	No.
Repulping	Pulper	4 units
Screening and separating	Johnson screen Closed cylinder screen Liquid cyclone	2 lines 2 lines 2 lines
Refining	1st refiner 2nd refiner	2 lines 2 lines
Thickener	1st cylinder filter 2nd cylinder filter	2 units 2 units

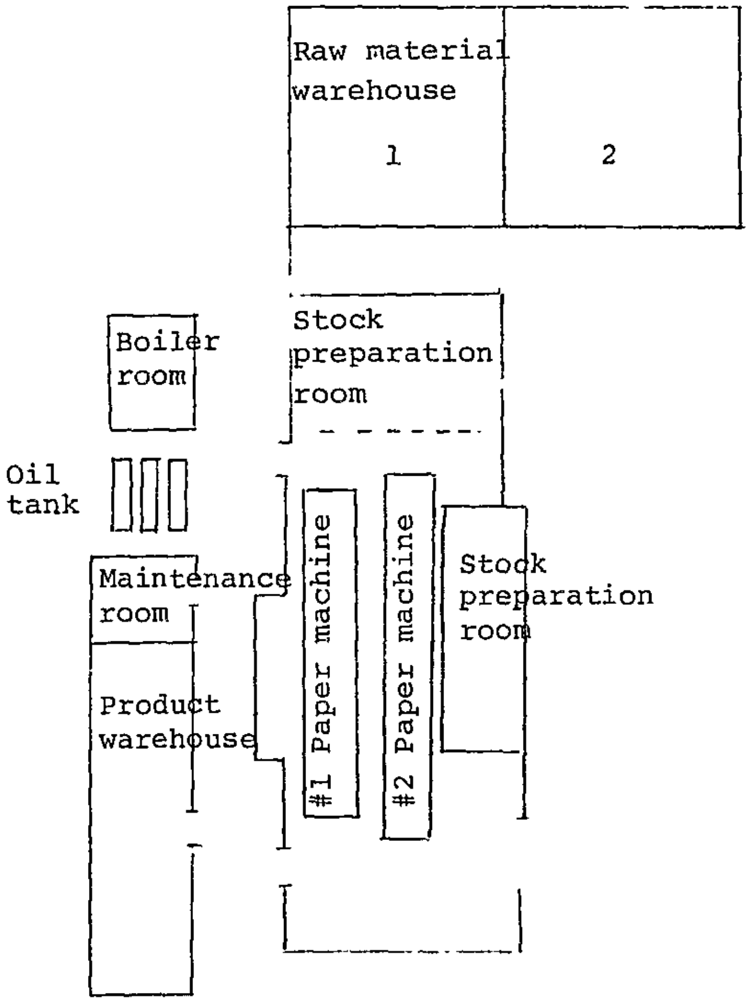
(2) Paper machine

Type	No.1 Paper machine		No.2 Paper machine	
	66" cylinder, multi-dryer type		72" cylinder, Yankee multidryer type	
Major equipment		No.		No.
Molder	Cylinder	5 units	Cylinder	5 units
Press	Baby press	3 sets	Baby press	3 sets
	Press	2 sets	Press	2 sets
Dryer	Cylinder (no hood)	18	Yankee (glazed)	1
			Cylinder (open hood)	12
Calender	1st stage roll	6	1st stage roll	6
	2nd stage roll	8	2nd stage roll	8
Cutter	Single	1 unit	Single	1 unit

(3) Boiler

Pressure	8.5 kg/cm^2G
Quantity of evaporation	6,000 kgs/h
Fuel	Fuel oil

(4) Layout



Raw material warehouse
1
2
Stock preparation room
Boiler room
Oil tank
Maintenance room
Product warehouse
#1 Paper machine
#2 Paper machine
Stock preparation room

4. State of Energy Management

Much has yet to be done to raise the level of paper making techniques. Despite the management's enthusiasm, energy consumption is not placed under good control due to lack of understanding of control methods.

It is desirable to set up a laboratory to allow better energy and quality control. In fact, a laboratory will bring about many advantages; for instance, it will be able to check the measured values of freeness and other factors as well as to furnish important data, such as the properties of stock before and after a refiner, and after a flow box and press, the dust-removing efficiency of a centricleaner, the dehydrating efficiency of a press, and results of ventilation testing in a hood. These data will be helpful in factory management to shape an equipment plan, work out a heat balance, and draw up a material control schedule, among others.

A log is prepared to record data on a boiler, but its entries are still insufficient to control the boiler's performenace. It is necessary to record more data including the quantity of feed water and fuel, the frequency of blowing, and temperatures of exhaust gases and others by providing feed water and fuel flowmeters.

One of the praiseworthy things about the facotry's management is that they are actively seeking proposals for improvement from employees.

5. State of Thermal Energy Consumption

Steam required for paper making is produced by the fuel oil-burning boiler with a capacity of 6 tons per hour. The consumption of fuel oil is 6,000 to 7,000 liters a day, so the fuel consumption rate runs at 180 to 200 liters per ton of paper. Although accurate figures are not available due to lack of a feed water flowmeter, the boiler's thermal efficiency is estimated at 82 percent.

Shown below is the heat balance in the No. 1 boiler.

Heat Balance in the No. 1 Boiler

Input (10^3 kcal/h, %)			Output (10^3 kcal/h, %)		
Heat of fuel combustion	2,638.4	99.7	Heat of steam	2,163.8	81.7
Sensible heat of fuel	8.6	0.3	Heat loss in exhaust gas	345.0	13.0
			Heat loss in blow water	5.8	0.2
			Heat release from boiler body	132.4	5.0
Total	2,647.0	100	Total	2,647.0	100

Notes:

1) Data given for determination of the heat balance -

Type of fuel	-	Fuel oil (specific gravity: 0.933)
Fuel consumption (F)	-	272 kgs/h
Heat contents of fuel (low level, Hl)	-	970 kcal/kg

Specific heat of fuel (C_P) - 0.45 kcal/kg °C

Temperature of fuel (T_F) - 100°C

Reference temperature (To) - 30°C

Oxygen content of exhaust gas (%, O_2) - 8.9%

Temperature of exhaust gas (T_G) - 240°C

Amount of blow water (B) - 45 kgs/h

Temperature of blow water (T_B) - 179°C

Temperature of feed water (T_W) - 50°C

Steam pressure (P) - 8.5 kgs/cm^2 G

2) Equations for calculating the heat balance -

<u>Input</u>

a. Heat of fuel combustion (Q_C) :

$Q_C = F \times Hl = 2{,}638.4 \times 10^3$ kcal/h

b. Sensible heat of fuel (Q_S) :

$Q_S = F \times C_P\ (T_F - To) = 8.6 \times 10^3$ kcal/h

<u>Output</u>

a. Heat loss in exhaust gas (Q_E) :

Theoretical amount of air (Ao) = $\frac{0.85\ Hl}{1{,}000} + 2.0 = 10.2$ Nm^3/kg

Theoretical amount of exhaust gas (Go) = $\frac{1.11\ Hl}{1{,}000} = 10.8$ Nm^3/kg

Air ratio (m) = $\frac{21}{21 - O_2} = 1.74$

Actual amount of exhaust gas (G) = Go + Ao (m - 1)

$= 18.3\ Nm^3/kg$

$Q_E = F \times G \times 0.33\ (T_G - To) = 345.0 \times 10^3$ kcal/h

b. Heat loss in blow water (Q_B) :

$Q_B = B \times (T_B - T_W) = 5.8 \times 10^3$ kcal/h

c. Heat release from boiler body (Q_R) :

Based on the assumption that it accounts for 5 percent of the input heat,

$Q_R = (Q_C + Q_S) \times 0.05 = 132.4 \times 10^3$ kcal/h

d. Heat of steam (Q_V) :

$Q_V = Q_C + Q_S - Q_E - Q_B - Q_R = 2{,}163.8 \times 10^3$ kcal/h

e. Quantity of steam evaporation (S) :

Enthalpy of steam (E_S) = 662.4 kcal/kg

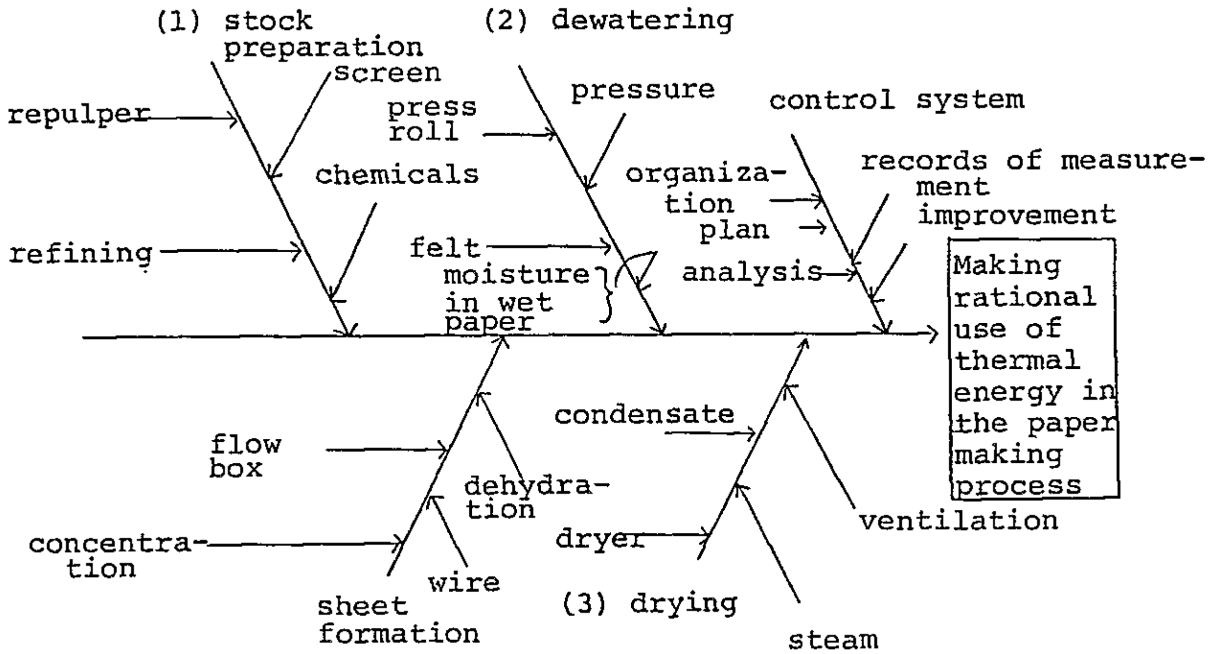
Enthalpy of feed water (E_F) = 50 kcal/kg

$S = Q_V \div (E_S - E_F) = 3{,}535$ kgs/h

6. Problems in Heat Control and Potential Solutions

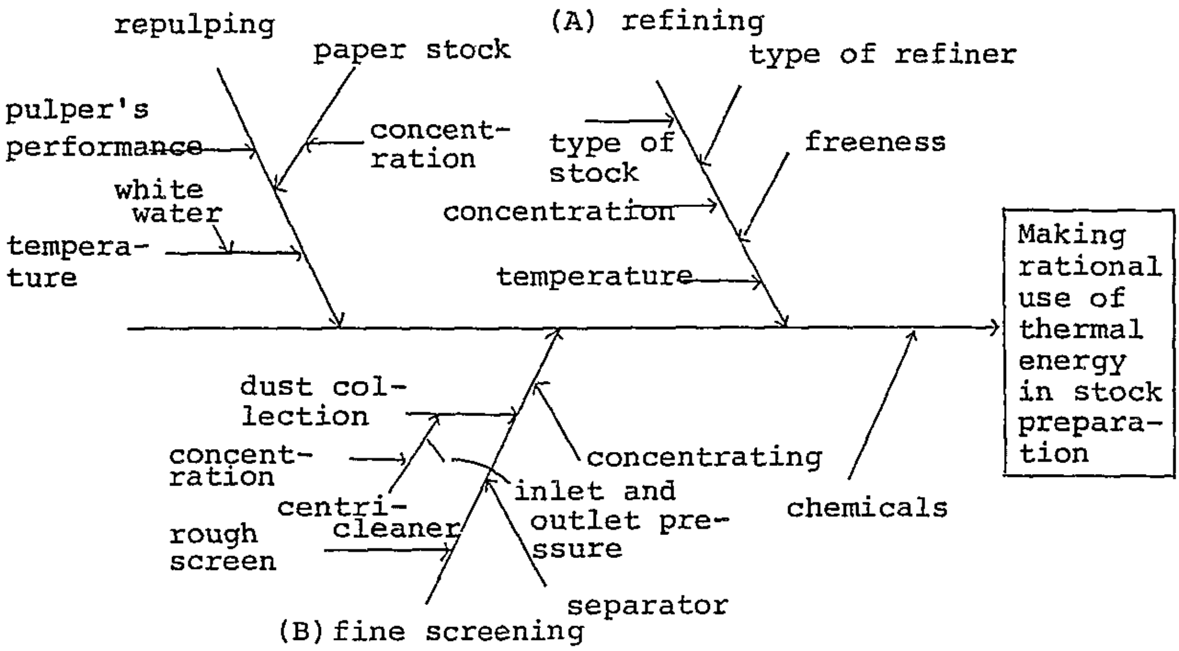
A paper making process is the one where pulp in 4 to 5 percent concentration will be given various forms of treatment such as screening of fibers and dust collection, and it will subsequently be homogeneously dispersed in water with the strength of 1/500 to 1/1,000 to make a sheet, and this sheet will finally be dehydrated and dried up. So it is one of the most electric as well as thermal energy consuming processes to absorb water from wet paper. It may well be said that factors involved in the paper making process are synonymous with parameters contributing to energy conservation.

In this section, we will discuss what should be done to make rational use of heat energy in the paper making process according to the diagram given below.



(1) Stock preparation

Points to be improved in stock preparation can be summarized in the following diagram.



A. Refining

No data on freeness are available; it should be measured by all means as it serves an important indicator showing how much stock is refined.

Most of the paper mills have the established standard values of this freeness and concentration of pulp. One of the important duties to be performed by an operator is to make the freeness and concentration of pulp consistent with the standard values. To do so, the concentration and freeness of pulp are measured in every shift for the former and every one or two hours for the latter, so that the concentration of pulp can be kept at a reasonable level by adjusting the quantity of white water and regulating the load on a refiner.

Preferably, pulp should be highly concentrated so far as the pump's capacity is not affected. This will eventually afford a saving of electric power. It is advisable to make measurement of the concentration and freeness of pulp and utilize such parameters for energy conservation as well as for quality control

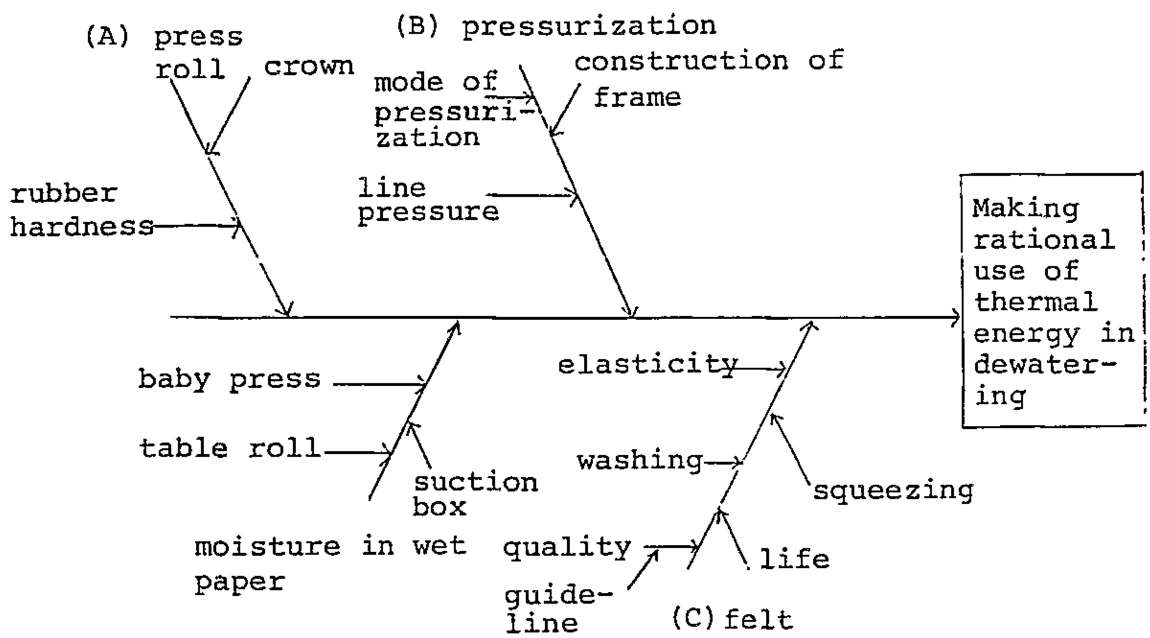
B. Screening

Deposits comprising dust and other foreign substances, if they get mixed in a sheet, will form blackish dirty spots called fish eyes as they contain a large amount of water. These fish eyes inevitably require a great deal of steam for elimination, resulting in overdrying; at the same time, they cause paper to lose its strength and become easily breakable. The removal of foreign matters and other unseparated substances from stock through screening, therefore, will obviously result in the prevention of overdrying in the dryer and hence economy of heat energy.

The centricileaner, a device for removing deposits, will not be able to run at full capacity and electric power will go to waste unless the concentration of pulp and inlet and outlet pressure levels are set as specified. In this regard, several points requiring an immediate action can be raised; for instance, the centricleaner's pressure gauge is out of order, it is placed in the wrong position, and no data on pressure are recorded. In addition, the centricleaner's inner, conical wall should be made smooth; otherwise, its function will be lowered. It is necessary to inspect it at regular intervals; it may have to be replaced by a smooth one. Taken together, the above remedies will afford a saving of 2 percent or more in steam.

(2) Press part

The following diagram shows a number of factors contributing to economy of energy in dewatering at the press part.



A 1 percent reduction in the water content of wet paper in advance will result in a saving of 3 to 5 percent in steam in the dryer. Currently, wet paper is estimated to contain about 60 percent moisture. Moisture at the wet end should be made clear by all means; it is advisable to make sampling at four spots or so in the cross direction to obtain the mean value and see how much moisture in wet paper varies from spot to spot.

A. Press roll

A crosswise variation in the water content of wet paper is mainly attributable to distortion of the roll's crown as well as to stains on a felt. Unless the crown is kept in proper shape, a drop in the total dehydrating capacity and partial overdrying would result. When the felt is renewed or the press roll is placed at rest for repair, therefore, the crown should be checked to see if it is in good shape and, if not, it should be replaced by a new one. Also, a rubber has to be inspected to see if it has a specified hardness.

B. Pressurization

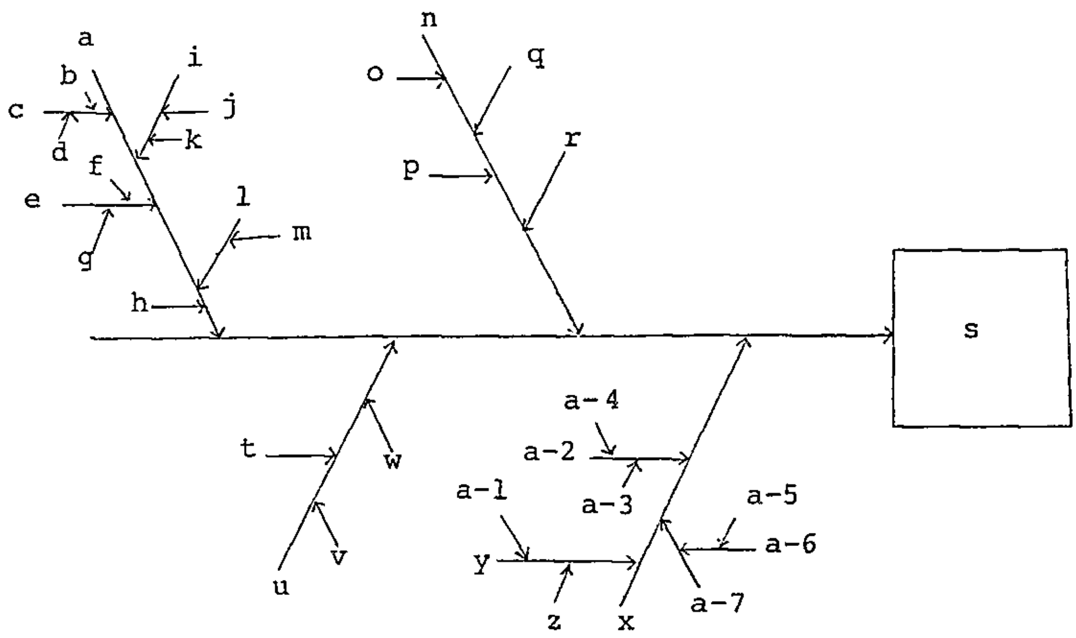
How to pressurize with the press roll is one of the most challenging tasks to be done by a paper machine tender. Forcible pressurization will cause the device to be damaged. To ensure effective pressurization, therefore, it is important to consult an equipment manufacturer about the strength of a roll frame. Also important is to pressurize wet paper little by little to reduce its water content while making the most of a suction box and baby press and paying good attention to quality.

C. Felt

A felt constitutes one of the important factors affecting dehydration. The felt comes into close contact with wet paper and is compressed by the press. Then the moment it is relieved from the nip's pressure, it quickly swells to restore its original form and, in so doing, absorbs water from wet paper. As such, the felt is required to keep its elasticity. To this end, it should be kept clean by making the most of showering and squeezing devices. If the water content of wet paper is reduced by 1 percent at the wet end through the above measures, it is expected that a saving of 4 percent or more in steam will be achieved.

(3) Dryer part

At the dryer part, the water content of wet paper is cut down from about 60 percent to 5 to 10 percent by means of steam drying. Shown below are a number of factors contributing to energy conservation at this part.



a. (A) dryer cylinder; b. close contact; c. surface heat transfer efficiency; d. doctor; e. condensate; f. condensate film; g. siphon; h. no. of units; i. steam; j. blow-in pressure (temperature); k. heat insulation; l. type; m. multicylinder type; n. (B) canvas; o. air permeability; p. canvas dryer; q. tension; r. hot air blow; s. Making rational use of thermal energy in the dryer; t. use of flash vapor; u. (D) condensate system; v. trap; w. heat insulation; x. (C) ventilation; y. hood; z. closed hood; a-1. open hood; a-2. exhaust; a-3. forced exhaust; a-4. natural exhaust; a-5. polarized air current; a-6. unevenness in drying; a-7. construction of hood

A. Dryer cylinder

For more efficiency in evaporation of moisture in paper in contact with a cylinder, consideration should be given to the following points:

a. To make a condensate film over the inner wall of the cylinder thin;

b. To allow closer contact between the cylinder surface and paper; and

c. To reduce heat resistance on the cylinder surface and between paper layers.

A siphon is designed to keep a drain film in the cylinder always thin. So it is advisable to open the cylinder's manhole and examine the siphon when it is placed at rest. A variety of highly efficient siphons are on sale these days. Bring them in, if possible.

As for the point b), it is necessary to keep the cylinder surface always smooth not to let the air in between the cylinder surface and paper, so that paper will come into closer contact with the cylinder surface and heat conductivity can be increased. To do so, the dryer surface as well as the doctor should be invariably inspected every day.

B. Canvas

A canvas is provided to allow closer contact between the cylinder surface and wet paper. In addition, it holds vapor given off by wet paper and let it loose in an open space from one cylinder to another. Functioning this way, therefore, the felt should not be clogged and it should be kept at high temperatures and dry. It is found that the temperature of the felt tends to drop due to the air coming in from outside when the felt returns. To prevent this, it is an effective measure to provide a polyethylene curtain on the side of the dryer.

C. Ventilation

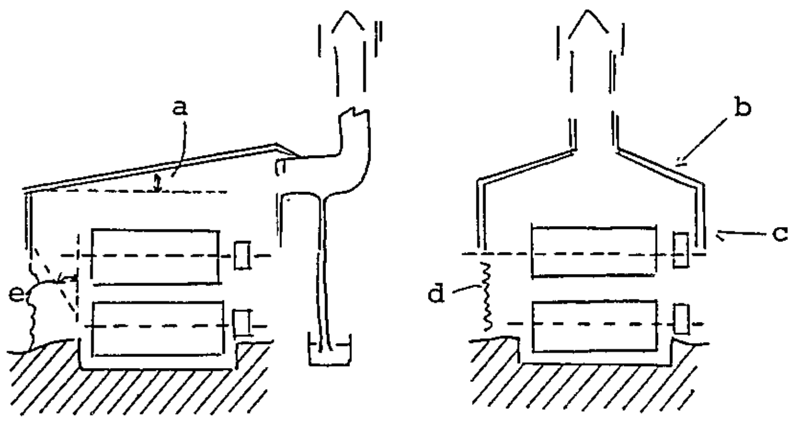
If the so-called dryer pocket - a section in the dryer surrounded by a cylinder, canvas, and sheets of paper - is poorly ventilated, then the partial pressure of water vapor standing still will go up, precluding the canvas from effective dehydration and drying.

When the humidity in the dryer pocket was measured, a hygrometer deflected greatly in the range between 50 and 90 percent due to the air coming in from outside as well as to vapor being flushed in from the center of the dryer. Such a great meter deflection indicates that ventilation is not satisfactory.

Vapor staying in the dryer should effectively be discharged by getting it displaced by the air from outside; at the same time, the amount of air should be reduced to the minimum. Generally, the amount of air required for making one ton of paper is supposed to be:

75 - 80 m^3 for the machine without hood;
50 - 60 m^3 for the machine with open hood; and
25 - 30 m^3 for the machine with closed hood.

One of the advantages that can be drawn from a hood is that it helps cut down heat loss as the sides of the dryer will be ventilated at a higher speed, accelerating the displacement of vapor in the dryer pocket and decreasing the amount of air coming in from outside. A hood is usually designed with due consideration to the air flow in a group of dryers. The idea is as illustrated below.



a. 21° or more; b. anticorrosive;
c. To be pulled down to such an extent that repair work will not be arrested; d. Polyethylene film (to be drawn up whenever paper breakage occurs)
e. 30° - 35°

When the machine is wide enough to do so, a pocket ventilation equipment - a Ross-Grewin hot air system or a hot air blow roll - is usually installed so that a hot dry air can be brought into the dryer pocket. This equipment costs dearly, however. So right now it will be enough just to keep it in mind as a future possibility. The first and immediate consideration should be to equip the machine with a hood. Moreover, as mentioned earlier, it is an effective measure to hang down a polyethylene film at the front part of the machine. It iwll help prevent a vapor flow from being disturbed by the air coming in from outside and arrest the release of radiant heat. Also, it may create a better working environment in the machine room.

The provision of a hood is expected to afford a saving of 8 percent in steam, accompanied with some merits such as improved quality and productivity.

D. Condensate system

To ensure effective condensate, a system should be contrived in this way: The dryer part is divided into two groups according to the flow of paper. Steam is then put into the second group of dryers; condensate produced there is guided into a flash tank; and flash vapor in the tank is fed into the first group of dryers, while condensate is brought into a boiler room. Such a condensate system is expected to afford a saving of 5 percent in steam.

An alternative is to feed condensate as it is under high pressure into a boiler using a condensate pump, rather than compressing the condensate.

(4) Boiler

Boiler accessories are almost kept in good order.

But meters and gauges are not satisfactorily calibrated, leaving some doubt as to the reliability of their readings.

The boiler is not fitted with feed water and fuel flowmeters but with an instantaneous steam flowmeter.

The oxygen content of exhaust gases stands at an excessively highlevel of 8.9 percent. A reduction in this oxygen content to 4.5 percent through adjustment of the air ratio will result in better combustion efficiency and less heat loss in exhaust gases as shown below.

Parameters	Current level	Improved level
Oxygen content of exhaust gases	8.9%	4.5%
Air ratio	1.74	1.27
Amount of exhaust gases per kg of fuel (at 220°C)	18.3 Nm^3/kg	14.2 Nm^3/kg
Heat loss in exhaust gases per kg of fuel	1.27×10^3 kcal/kg	0.99×10^3 kcal/kg

Supposing that input heat per kg of fuel is 9.73×10^3 kcal/kg and output heat other than heat loss in exhaust gases remains at a fixed level, the amount of fuel will be decreased by:

$$\frac{9,730 - 1,270}{9,730 - 990} = 0.968$$

Therefore, fuel can be saved by 3.2 percent.

Shown below are data on the quality of feed water and boiler water.

	Feed (soft)water	Boiler water
pH	7.06	11.73
Electric conductivity	710 μs/cm	4,397 μs/cm
Cl^-	77 ppm	432 ppm
Phosphate anion		14.5 ppm
Total dissolved solids	360 ppm	
Total residues after evaporation		2,237 ppm

Phosphate anion in boiler water should better be increased to 20 to 40 ppm. It is necessary to analyze the quality of feed and boiler water at least once a month as it affects the service life of a boiler. Also, flowmeters should be fitted into both a boiler feed water line and a soft water line leading to a feed water tank, so that the quantity of condensate recovered can be placed under control. And look into the ratio of the amount of feed water to that of fuel every day; if this ratio is found to be on a lower level than required, find the cause and take some proper action.

Currently, water is run through a water softening plant for 25 hours and the plant is given back washing for three hours. But the total hardness runs at 73 ppm (dH: 3.4), indicating that water is not satisfactorily softened. It is necessary to clean the water softening plant inwardly once a year.

Speaking of fuel oil, a little heavier oil with the specific gravity of 0.96 to 0.97 will serve the purpose sufficiently; such heavier oil costs less and has a larger heat contents per liter.

Working steam pressures should be reduced to as low a level as possible, so that heat can be more effectively used. Since steam pressures are good enough at 3.5 to 4 kgs/cm^2, it will be better to lower the boiler's source pressure level as well for energy-saving purposes.

(5) Steam piping

The reuse of used felts as insulating materials is one of the indications that the factory people are buckling down to the challenging task of conserving energy. Yet insulating materials applied outdoors need to be made waterproof as they will lose their insulation effects if get wet. To do so, it is advisable to cover them with aluminum films (with adhesives, a thickness of about 0.05 mm).

Valves, a steam header, and oil service and condensate tanks should be insulated. A reduction in heat loss that can be achieved by insulating valves is calculated at:

	Heat loss		Area (m^2)	Reduction in heat loss (kcal/h)
	Not insulated ($kcal/m^2h$)	Insulated ($kcal/m^2h$)		
Valves and flanges 6" x 3	2,440	70	3.6	8,532

This means that fuel can be saved by 13 kgs/h. The front part of the boiler should also be insulated as the temperature and heat flux show rather high levels of 126°C and 2,040 $kcal/m^2h$ respectively.

With improved and added steam traps, condensate are now being recovered under an open system. The problem is, however, that since a return pipe for condensate is buried underground, there is no way of seeing if it is eaten away with rust and develops condensate leakage. The temperature of feed water stands at a rather low level of 50°C, which seems to be due to a drop in the condensate recovery rate or poor insulation of the pipe.

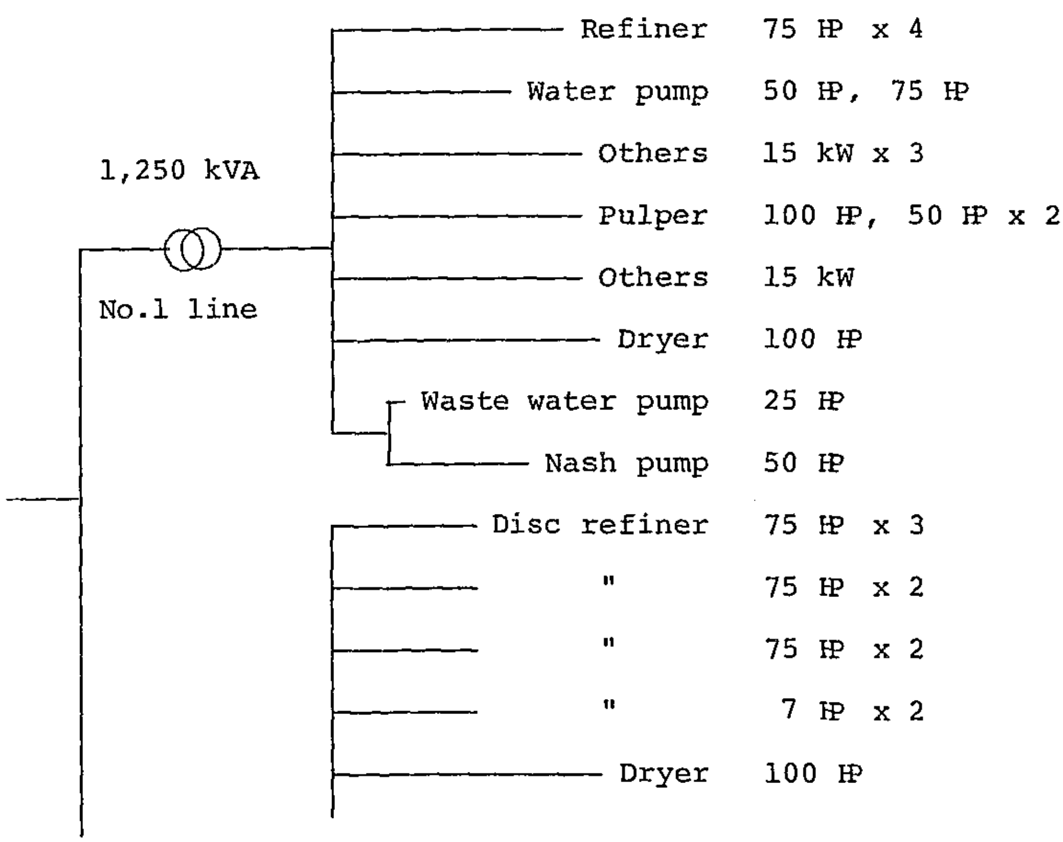
Almost no steam escape was observed, with the exception of the valve of a 6-inch main steam pipe leading to the paper machine room. This valve should be fixed right away. Suppose that steam is escaping through a hole of 2 mm in diameter under pressure of 8.5 kgs/cm^2G. Then, an escape of steam is calculated at 15 kgs per hour.

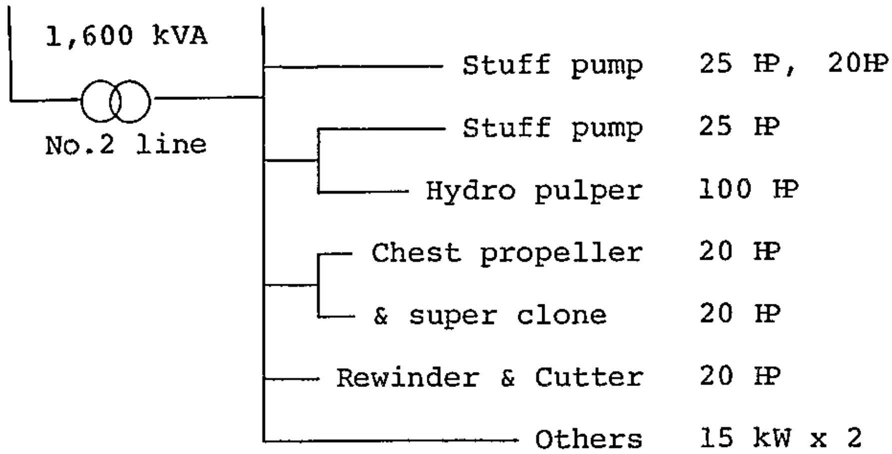
7. State of Electric Power Consumption

(1) The principal data relating to power consumption are as follows:

Power company	-	PEA
Peak demand	-	Not available
Power consumption	-	632,775 kWh/m
Load factor	-	Not available
Penalty	-	No
Power factor	-	81.8%
Transformers	-	1,250 kVA for No. 1 line 1,600 kVA for No. 2 line
Power consumption rate	-	703 kWh/t of paper

(2) One-line diagram





8. Problems in Electric Power Control and Potential Solutions

(1) Power factor

No attempt is made to improve the power factor using condensers. According to the results of our measurement, power levels of the 1,250 kVA and 1,600 kVA transformers are:

289.2 + j201.1 for the 1,250 kVA transformer; and

50 + j 37.4 for the 1,600 kVA transformer.

So the combined power is:

$$\dot{P}a = 339.2 + j238.5$$

The apparent power is:

$$|Pa| = 414.7$$

$$\cos\theta = \frac{339.2}{414.7} = 0.818$$

Based on these data, the power factor can be calculated at 81.8 percent. Now let it be supposed that a total of eight 100 kVr condensers are installed and turned on and off by relays for every 100 kVr. In this case, if the power factor at the average power of 1,055 kW (results for August) is assumed to be 80 percent, the reactive power will amount to 791.3 kVr. Then, if the condensers of 600 kVr are put into operation, the combined power will reach the level of 1,055 + j(791.3 - 600). Accordingly, the reactive power and the power factor will be improved to 1,072 kVA and 98.4 percent respectively. In this connection, it is advisable to install a power factor meter and a watt-meter at the transformers' main panel to be able to keep an eye on the power factor after examination of the capacity of CT and PT.

(2) Transformers

If the power factor is raised to 90 percent or higher with condensers, then it will be possible to combine all the load into a single 1,600 kVA transformer. The transformer's loadable capacity will be: 1,600 kVA x 0.9 = 1,440 kW, a level more than enough to cover the average power (1,055 kW).

This measure could save power loss in the 1,250 kVA transformer. An estimated saving of power loss (L) is as follows:

- Iron loss in the 1,250 kVA transformer (L1):

  L1 = 4.2 x 365 x 24 = 36,792 kWh/y

  (Provided that iron loss is assumed to be 4.2 kW.)

- Copper loss in the 1,250 kVA transformer (L2):

$$L2 = 13.5 \times (\frac{563}{1,250})^2 \times 341 \times 24 = 27,621 \text{ kWh/y}$$

(Provided that the unit is supposed to be run for 341 days a year.)

- Increase in copper loss in the 1,600 kVA transformer (L3):

$$L3 = 16 \times \left\{ (\frac{1,072}{1,600})^2 - (\frac{750}{1,600})^2 \right\} \times 341 \times 24$$

$$= 30,012 \text{ kWh/y}$$

- L = L1 + L2 - L3 = 34,092 kWh/y

The cost of condensers is estimated at bout 200, 000 bahts.

(3) Voltage

The secondary voltage of the 1,250 kVA transformer in the No. 1 line now stands at 380 V. It should be raised to 390 V in view of a voltage drop between the transformer and motors.

Meanwhile, the secondary voltage of the 1,600 kVA transformer in the No. 2 line runs at 400 V, which should preferably be dropped to 390 V. Put voltage changes on record hourly to see if they are of temporary nature, and you will be able to identify the trend in voltage changes and learn whether or not the transformer's secondary voltage is kept at a proper level.

In this respect, it is advisable to record not only voltage but also electric currrent, kW and the power factor. If kW and the power factor are made known, it will be possible to reckon the level of KVA on the transformer and to check up on readings of meters including a voltmeter and an ammeter.

(4) Operation of motors

Two of the motors are being operated below 50 percent of the rated current: 43.4 percent for the Nash pump (50 HP) in the No. 1 line and 28.3 percent for the paper machine's dryer (100 HP) in the No. 1 line.

The table below shows how motors are being operated. If the load current is at a lower level than the rated one, find the cause and carry out some proper remedies such as reducing the number of motors in operation or making them smaller in capacity.

Operation of motors

No. of line	Used for:	Output HP	Rated Current Ⓐ	Load Current Ⓑ	Ⓑ/Ⓐ %	Power facotr %
1	Nash pump	50	71 A	30.8 A	43.4	63
	Waste water pump	25	37	18.7	50.5	60
	Paper machine dryer	100	135	38.2	28.3	40
	Pulper	50 x 2	124 each	stop		
	"	100	not sure	stop		
	Water pump	75	103	98.3	95.4	86
	"	50	not sure	stop		
	Refiner	75 x 2	109 each	stop		
	"	75 x 2	105 each	stop		

	Pulp pump	20 x 2	29 each	stop		
	Pulper	100	133	80	60.2	80
	Water pump	25	35	stop		
2	Paper machine dryer	100	133	stop		
	Refiner	75	103	90	87.4	86
	"	75	103	90	87.4	86
	"	75	103	70	68	83
	"	75	103	70	68	83

(5) Lighting

For lighting, fluorescent lamps are provided, of which about 70 percent are daylight lamps. If they are replaced by white light ones, the luminous flux will be increased by 10 percent, making it possible to reduce the number of lamps by 10 percent. A total of 86 fluorescent lamps are of 40 W (those consisting of a pair of 40 W account for 20 percent of the whole). With the introduction of white light lamps, electric energy can be saved by:

0.04 kW x 86 lamps x 1.4 x 12 h/d x 341 d/y x 0.7 x 0.5 = 6,897 kWh/y

9. Summary

The above mentioned remedial measures, if actually taken, are expected to bring about energy-saving effects as shown below:

Measures	Potential energy saving	Rate(%)
Improvement on refining and screening	fuel oil 40 kl/y	2
Reduction in moisture (1%) at the wet end through improved dehydration at the press part	fuel oil 81	4
Provision of dryer hood	fuel oil 161	8
Recovery of condensate using flash vapor	fuel oil 101	5
Better insulation of piping and valves	fuel oil 20	1
Improved air ratio of the boiler	fuel oil 64	3
Subtotal	467	23
Equipment operation with a single transformer	power 34,092 kWh/y	
Adoption of highly efficient lamps	power 6,897 kWh/y	
Subtotal	40,989 kWh/y	0.5

Report No. 14: Paper

REPORT ON THE DIAGNOSIS

FOR

ENERGY CONSERVATION

- V-Sang Thai Paper Factory Co., Ltd. -

January, 1983

Japan International Cooperation Agency

Contents

The Diagnosis for Energy Conservation

- V-Sang Thai Paper Factory Co., Ltd. -

1. Outline of the Factory

Address : 23 Moo 2, T. Meanfuri, A. Meanfuri, Bangkok

Type of industry : Paper

Major products : Kraft paper

Annual output : 7,500 t

No. of employees : 190 (worker), 15 (staff) } 205 (total)

Annual energy consumption :

- Electric power : 7,317,073 kWh
- Fuel
  - Fuel oil : 2,046 kl

Interviewees : Mr. Bopna, managing director, Mr. Ram and Mr. Lin, chief engineer

Date of Diagnosis : Sept. 15 - 16, 1982

Diagnosers : A. Koizumi, K. Nakao, and K. Kurita

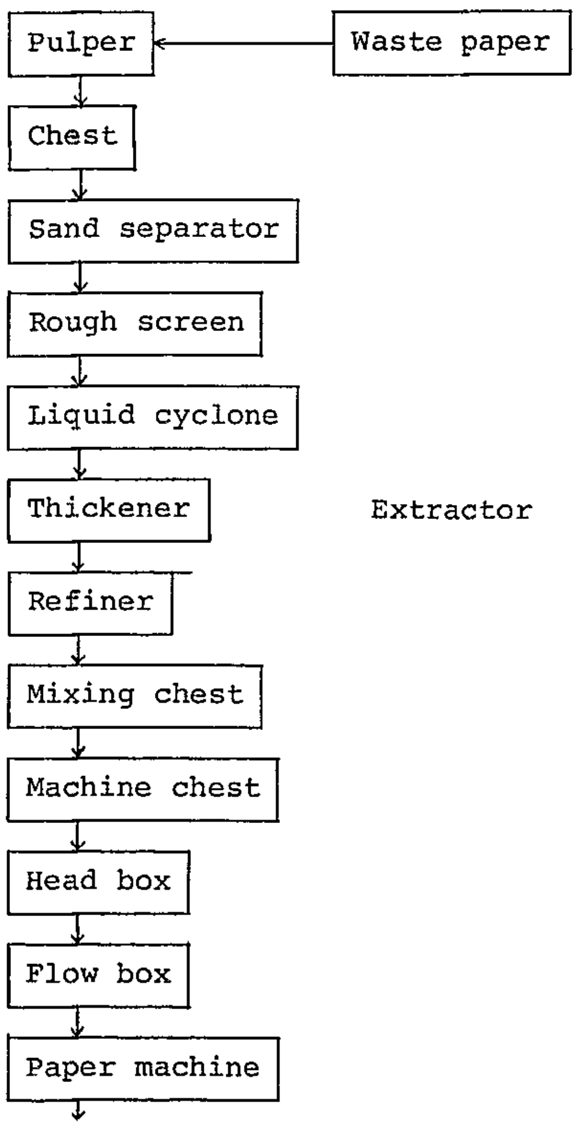
They are now energetically trying to improve the management of the factory that was handed over to them one year ago. Striving for a reinforced control system, they are trying to ensure quality control and maintenance and promote employee training.

The president and production, technical and finance managers are all Indian experts, whose positive management attitude is worthy of note. They will shortly invite an Indian consultant team to consider measures for them to renovate or modify factory equipment.

Most of the raw materials they use are waste paper. Some unbleached kraft pulp (UKP) is also in use.

They produce 25 t/d of cardboard and rapping paper.

2. Manufacturing Process



Calender

↓

Cutter

3. Major Equipment

(1) Stock Preparation

Process	Equipment
Repulping	Pulper 3 units
Screening and separating	Riffler 1 set Johnson screen 1 set Liquid cyclone 2 sets
Beating and refining	Disc refiner conical refiner 2 sets
Thickener	Cylinder filter 1 unit

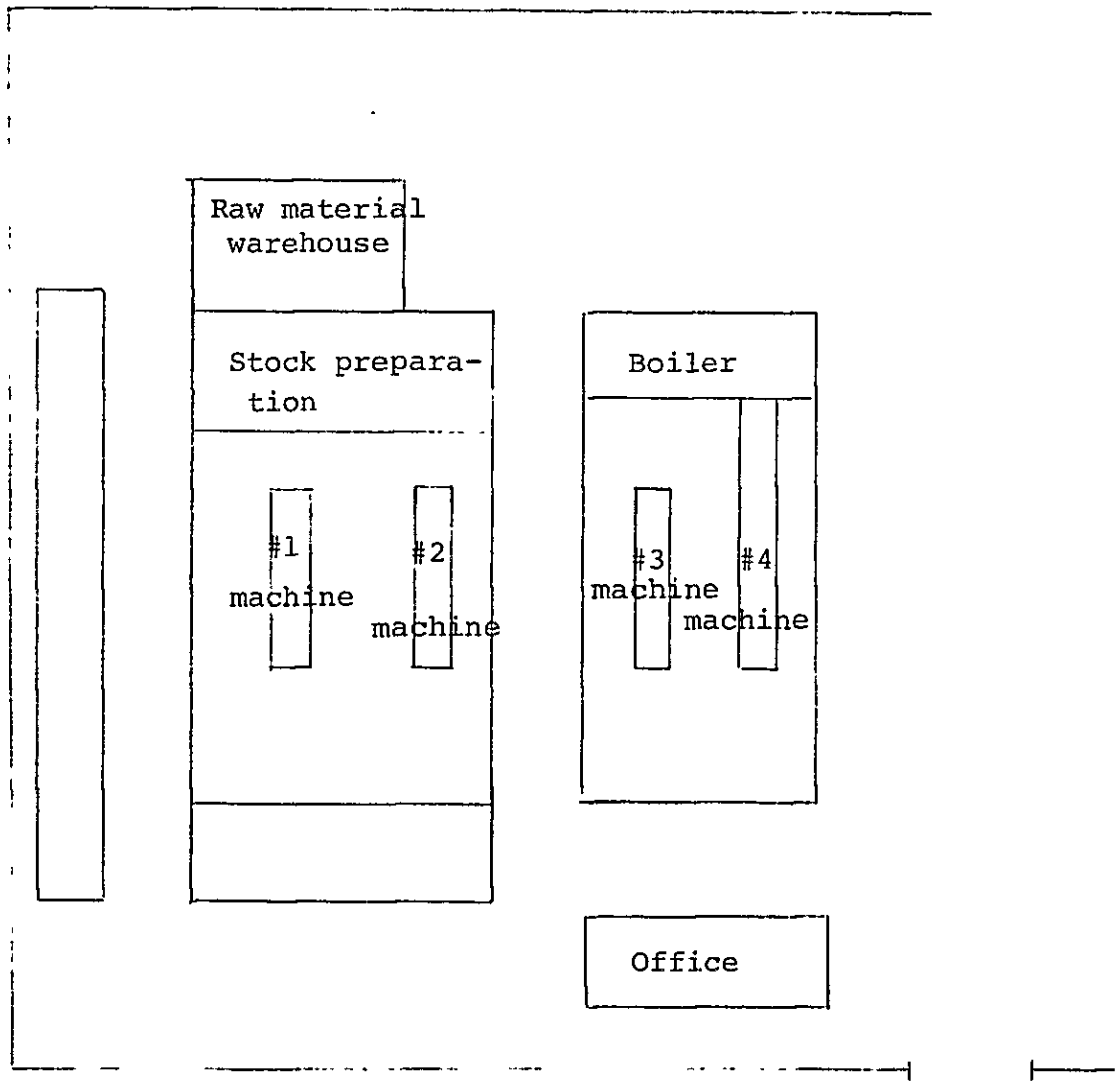
(2) Paper machine

	Type	Mould	Press	Dryer	Calender
No. 1 machine	82" 2-cylinder Yankee type	2	2	Yankee 2	8 Rolls
No. 2 machine	60" 2-cylinder Yankee type	2	1	Yankee 2	8 Rolls
No. 3 machine	62" 2-cylinder Yankee type	2	1	Yankee 2	-
No. 4 machine	60" multi-cylinder Yankee type	2	2	Yankee 19 Cylinder 6 (no hood)	6 Rolls -

(3) Boiler

	Pressure	Steam generating capacity
No. 1 boiler	8 kg/cm^2G	3 t/h
No. 2 boiler	"	2.5 t/h

(4) Layout



4. State of Energy Management

They are in process of improving equipment. Under plans for a fuel changeover, they plan to replace their fuel oil boilers with lignite-burning ones. They are also improving the paper machine condensate system and the waste water treatment process.

They are among the most advanced Thai paper manufacturers in the matter of efforts toward quality control and factory management. But it would appear that they still have to catch up on their technique and capability to have command of equipment.

Records of operation, analysis of water and other data on boilers are kept very well on file. Factory leaders are active in compiling statistics from basic data, but they still have to learn how to make use of the data and figures.

Instrumentation is generally inadequate and out of repair.

5. State of Fuel Consumption

Two fuel oil boilers provide steam for the papermaking heat source.

Oil consumption runs at:

3,370 liters/d for No. 1 boiler

3,450 liters/d for No. 2 boiler

with a fuel consumption rate of 273 liters per ton of paper.

The quantity of steam generated is estimated at 3.7 t/h with a steam consumption rate of $\frac{3.7 \times 24}{25}$ = 3.55 t/t of paper.

Shown below is the heat balance in the No. 1 boiler.

<u>Heat Balance in the No. 1 Boiler</u>

Input (10^3 kcal/h, %)			Output (10^3 kcal/h, %)		
Heat of fuel combustion	1,300.6	99.8	Heat of steam	1,035.6	79.4
Sensible heat of fuel	3.0	0.2	Heat loss in exhaust gas	195.6	15.0
			Heat loss in blow water	7.2	0.6
			Heat release from boiler body	65.2	5.0
Total	1,303.6	100	Total	1,303.6	100

Notes:

1) Data given for determination of the heat balance -

Reference temperature (To)	-	30°C
Type of fuel	-	fuel oil
Temperature of fuel (T_F)	-	80°C
Fuel consumption (F)	-	135 kg/h
Heat contents of fuel (low level, Hl)	-	9,634 kcal/kg
Oxygen content in exhaust gas (%) (O_2)	-	10%
Temperature of exhaust gas (T_G)	-	250°C

Steam pressure - 8 kgs/cm^2G

Temperature of feed water - 78°C

Amount of blow water - 50 kg/h

2) Equations for calculating the heat balance -

<u>Input</u>

a. Heat of fuel combustion

135 kgs/h (F) x 9,634 kcal/kg (Hl) = 1,300.6 x 10^3 kcal/h

b. Sensible heat of fuel

135 kgs/h (F) x 0.45 kcal/kg (specific heat of fuel) x [80°C (T_F) - 30°C (To)] = 3.0 x 10^3 kcal/h

<u>Output</u>

a. Heat loss in exhaust gas

Theoretical amount of air (Ao) =

$$\frac{0.85\ Hl}{1,000} + 2.0 = 10.19\ Nm^3/kg \text{ of fuel}$$

Theoretical amount of exhaust gas (Go) =

$$\frac{1.11\ Hl}{1,000} = 10.69\ Nm^3/kg \text{ of fuel}$$

$$\text{Air ratio (m)} = \frac{21}{21 - O_2} = 1.91$$

Actual amount of exhaust gas (G) =

Go + (m - 1)Ao = 19.96 Nm^3/kg of fuel

Heat loss in exhaust gas =

135 kgs/h (F) x 19.96 Nm^3/kg (G) x 0.33

x [250°C (T_G) - 30°C (To)]

= 195.6 x 10^3 kcal/h

b. Heat loss in blow water

Amount of blow water = 50 kgs/h

Temperature of blow water = 174°C

Heat loss in blow water

= 50 x (174 - 30) = 7.2 x 10^3 kcal/h

c. Heat release from boiler body

5 percent of the total amount of input heat is accounted for by heat release from the boiler body.

1,303.6 x 10^3 x 0.05 = 65.2 x 10^3 kcal/h

d. Heat of steam

1,303.6 x 10^3 kcal/h (total amount of input heat)

- 195.6 x 10^3 kcal/h (heat loss in exhaust gas)

- 7.2 x 10^3 kcal/h (heat loss in blow water)

- 65.2 x 10^3 kcal/h (heat release from boiler body) = 1,035.6 x 10^3 kcal/h

e. Quantity of evaporation

Quantity of evaporation =

$$\frac{1{,}035.6 \times 10^3 \text{ kcal/h (heat of steam)}}{661.93 \text{ kcal/kg (enthalpy of steam)} - 77.988 \text{ kcal/kg (enthalpy of feed water)}}$$

= 1,774 kg/h

Shown below is the heat balance in the No. 2 boiler.

Heat Balance in the No.2 Boiler

Input (10^3 kcal/h, %)			Output (10^3 kcal/h, %)		
Heat of fuel combustion	1,329.5	99.8	Heat of steam	1,108.0	83.2

Sensible heat of fuel	3.1	0.2	Heat loss in exhaust gas	150.8	11.3
			Heat loss in blow water	7.2	0.5
			Heat release from boiler body	66:6	5.0
Total	1,332.6	100	Total	1,332.6	100

Notes:

1) Data given for determination of the heat balance -

Fuel consumption (F) - 138 kg/h

Oxygen content in exhaust gas (O_2, %) - 5.6%

Temperature of exhaust gas (T_G) - 260°C

* Other data are the same as for the No. 1 boiler.

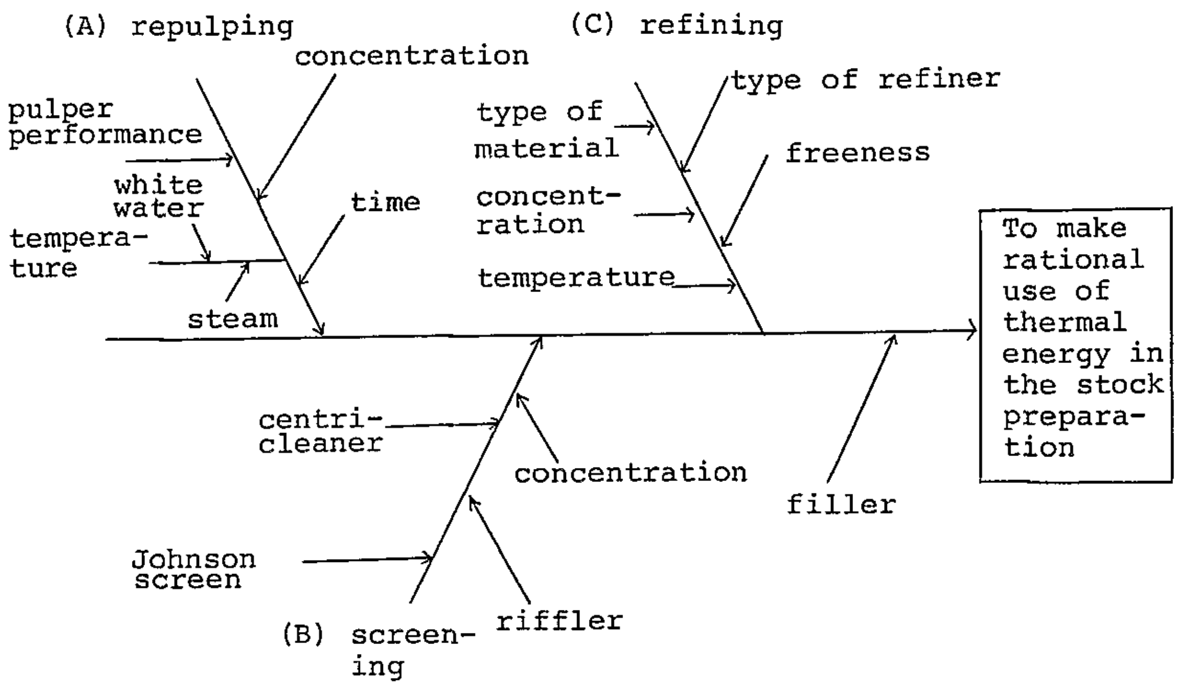
$$\text{Quantity of evaporation} = \frac{1{,}108.0 \times 10^3 \text{ kcal/h}}{661.93 - 77.99 \text{ kcal/h}}$$

$= 1{,}897$ kg/h

6. Problems in Heat Control and Potential Solutions

(1) Stock preparation

Heat energy rationalization of this process can be plotted out in the following factor chart:



A. Repulping

The conditions of waste paper repulping in this factory are:

Concentration - 3.5%

Temperature - 40°C

Time - 30 minutes

The temperature requirement of 40°C is being filled by blowing in live steam in amounts equal to about 10% of all steam in the factory.

The effect finds expression in the following table of pulper temperature measurements which indicate that temperature differs from pulper to pulper:

Pulper	No.1	No.2	No.3	No.4
Temperature (°C)	31	37	29	48

The temperature of paper stock seems to be about 25°C. Using nothing but white water to adjust the pulp concentration, they could keep the temperature at 34°C in the pulper. The pulper temperature varies either because something is wrong with the white water circuit or because raw water of 25 - 27°C is used for working water. Operators are advised to review the white water circuit and to check up the water from paper machine is in normal condition running counter to the flow of stock. If the white water temperature can be kept up, data for measurement show that it will be possible to save more than 20% on the amount of steam used for the adjustment of pulper temperatures, thus achieving a saving of 2% for all the factory.

B. Screening

The separation effect of liquid cyclones, such as the centricleaner, depends on whether or not they are being operated in keeping with the inlet concentration of stock, the inlet pressure of stock, the outlet pressure of stock and the inner smoothness of the cyclone as required specifically for each of the machines. In this factory, they have no pressure gauges for operation monitoring, nor does it seem that they have ever made internal checks.

If the machines in operation have a bad dust removing effect as they are out of good working order, it means a waste of power. If deposits are mixed in the sheet, it means a waste of steam to the dryer as it will have to be worked up to over-drying. It's advised to fit pressure gauges to cleaners so that the machines will be operated under good conditions.

C. Refining

No provision has been made for the degree of refining and the conditions of operation. The electric power consumption of refiner is very large. Some pulp is easy to refine and some are not, but if it is not refined to some extent, it will cause dehydration and drying to vary in degree in the process that follows. It will also cause quality to vary.

The degree of refining is expressed by freeness. Even when the freeness is constant, the pulp concentration must also be constant because the conditions of dehydration and drying change with the concentration at the time of refining.

To make effective use of the electric power for refining and of the drying steam in the dryers, operators are advised to make arrangements for freeness control and concentration control.

We hope they will soon get the freeness testers which we hear they are planning to buy.

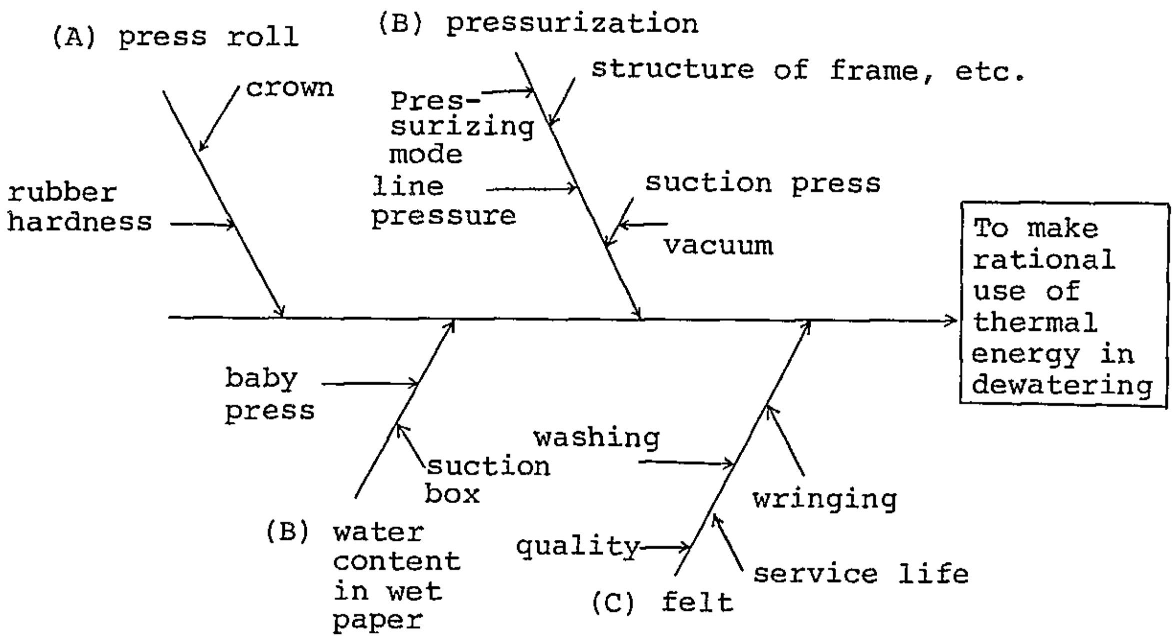
Screening and refining could be expected to be improved until they could effect a steam saving of

2% or more.

(2) Press part

It is very good that they are testing the press part to confirm the water content of the wet web. But they are advised to make a steady approach by checking on the strength of the equipment frame, because there have been cases where an excessive effort at dehydration in the press resulted in a rupture of the equipment, making it impossible to continue production.

Intensified dehydration in the press part would produce a vast energy-saving effect. 1% reduction of water content after the press part process is said to be able to effect a saving of 3 - 5% in the amount of steam used by dryer. Given 59% water content as measured under test, 1% reduction means a steam saving of about 5%. The following chart shows the factors of energy rationalization in the press which we hope will be recombined in ways that meet actual conditions so that the water content of the wet web will be reduced.



A. Press roll

The shape of the crown and rubber hardness are as planned for the roll, but they must be inspected periodically.

B. Smaller the water content of the wet web that enters into the press, less the burden on the press. The baby press, which is out of operation, should be utilized.

C. Felt

The felt washing shower is working very well, but the squeeze is not well dehydrated. Cleaner the felt, better the dehydration effect.

(3) Dryer part

One cylinder is enough for the Yankee dryer to do the drying fast and effectively.

Two big points in drying by Yankee dryer are:

a. A greater drying effect if thermal conductivity is raised by using a touch roll to make the wet web stick fast to the dryer surface,

b. Economy in the amount of steam used if evaporation is promoted and the drying rate accelerated by running hot and fast jet air through the back of the wet web.

In the case where there is no need to let products have right-and-wrong side and luster variations, a raise in thermal conductivity will save some amount of steam if the touch pressure of the Yankee dryer is raised. It might be advisable to fit the Yankee dryer with a bigger pressure feed bolt instead of the one in use as it seems to be weak in intensity. The way it is with a space left open in front of the hood, the function as mentioned above in (b) does not work. An effective use for the equipment would get it back in normal condition and could achieve a saving of 2% or more in the amount of steam used.

(4) Boiler

A. Feed water

There are no feed water flow meter fixed on No. 1 and No. 2 boilers. The boilers cannot be kept under performance control if there is no way of finding the quantity of feed water needed to determine the rate of evaporation and the value of boiler efficiency.

The rate of evaporation is calculated under the formula: $\dfrac{\text{Quantity of evaporation}}{\text{Quantity of fuel consumption}}$

When the rate of evaporation is estimated from the value of heat balance,

No. 1 boiler $\gamma e = \dfrac{1,774}{135} = 13.14$ kg steam/kg oil

No. 2 boiler $\gamma e = \dfrac{1,897}{138} = 13.75$ kg steam/kg oil

It does not make difference to the performance control if calculations are made with the fuel flow in terms of liters/h. If $\gamma e = 13$ kg steam/liter oil in this case, boiler efficiency probably works out at 80 - 85%.

B. Water quality

The quality of feed water and boiler water is set out below:

		No.1 boiler	No.2 boiler
Feed water	Total dissolved solids	135 ppm	
	Cl^-	28.6 ppm	
Boiler water	Ion phosphate	38.5 ppm	44.6 ppm
	Total evaporated residues	4,583 ppm	4,798 ppm
	Cl^-	206.4 ppm	160 ppm

The above analytical values are good. The water softener is in good working order, and consumption of chemicals and the amount of blow are appropirate.

If possible, it might be desirable to install a sand filter in ways that put it before the softener. It must be made sure that softened water is used to rinse the softener.

C. Air ratio

It might be advisable to see that the proportion of O_2 in exhaust gas is not higher than 5%.

No. 1 boiler shows the equivalent of 10% with a high air ratio of 1.91. Since this increases waste gas losses and causes combustion efficiency to decline, good adjustment must be made to the secondary air and the damper.

When the proportion of O_2 falls to 4.5%, the amount of fuel used declines to 7.3 kg/h = 183 liters/d (2.7%).

No.2 boiler needs some more adjustment as it shows 5.6%.

D. The pressure gauge on No. 1 boiler gives wrong readings. The water level gauge is in bad order, too. These should be made good before they cause an accident.

(5) Steam piping

A. Insulation

Boiler steam valves and steam header inlet and outlet valves should be insulated.

Operators are advised to make good the bad insulation of 4" pipes in the boiler room, 3" pipes (about 45 meters) in the factory and small pipes around the paper machine.

Perfect insulation of the above-mentioned valves and pipes would reduce the heat loss as follows. This would be equivalent to 1.4% of the amount of fuel oil consumption.

	Heat loss		Area or length	Heat loss reduced by:	Potential energy saving
	Without insulation	With insulation			
4" valve, flange in 4 locations	2,270 kcal/ m^2h (155°C)	72 kcal/m^2h (45°C)	3 m^2	6,594 kcal/h	534 liters/ m
3" pipe	634 kcal/ m^2h (155°C)	24 kcal/m^2h (45°C)	45 m	27,450 kcal/h	2,223 liters/ m
Total				34,044 kcal/h	2,757 liters/ m

B. Steam leakage

There are many cases where steam leaks from rotary joints in the paper machines and dryers, from joints in the branch pipes and from valves in the 3" pipeline.

Steam leakages can be estimated at 6,480 kg/m or the fuel equivalent of 510 liters/m.

Repairs should be made immediately.

C. Steam trap

Steam traps play an important role in the steam-using equipment. Unless they are kept in proper repair, they could leak steam and waste energy.

One way to keep them in good repair is to give a number to each trap and make out a control schedule so as to make checks at regular intervals (every three or six months.).

Some particular weeks might be fixed for a steam trap check-up by all employees in the factory.

D. Paper machine instrumentation

Steam pressure gauges were found to be in bad order. They should be repaired. Steam should be used in low pressure as possible.

(6) Condensate recovery

A. Condensate recovery is under way, but they say the quantity of recovery is not know. It may be estimated from Cl^- in the analysis table on the quality of feed water that the condensate is being recovered at the rate of 50%.

From Report, June 21, 1981

	Treated water	Feed water
Cl^-	19.3 ppm	9.6 ppm

The condensate pipe running from paper machine to condensate tank must be insulated to preclude a heat loss.

A flow meter should be fixed on the treated water line. It might be designed to indicate rates of condensate recovery so that they can be controlled and recorded.

B. Use of flash steam

Considerable energy economy will be practiced at the level of condensate recovery from the paper machine if steam pressure is changed, according to the quantity of heat needed for each dryer, to use high-pressure steam on the last part of the dryer so that the condensate from it will be sent to the flash tank to find use for flash steam in the preceding part of the dryer. This process will effect a saving of 10 - 15% in steam. The feed water tank containing recovered condensate should be constructed in such a way as to prevent its overflow.

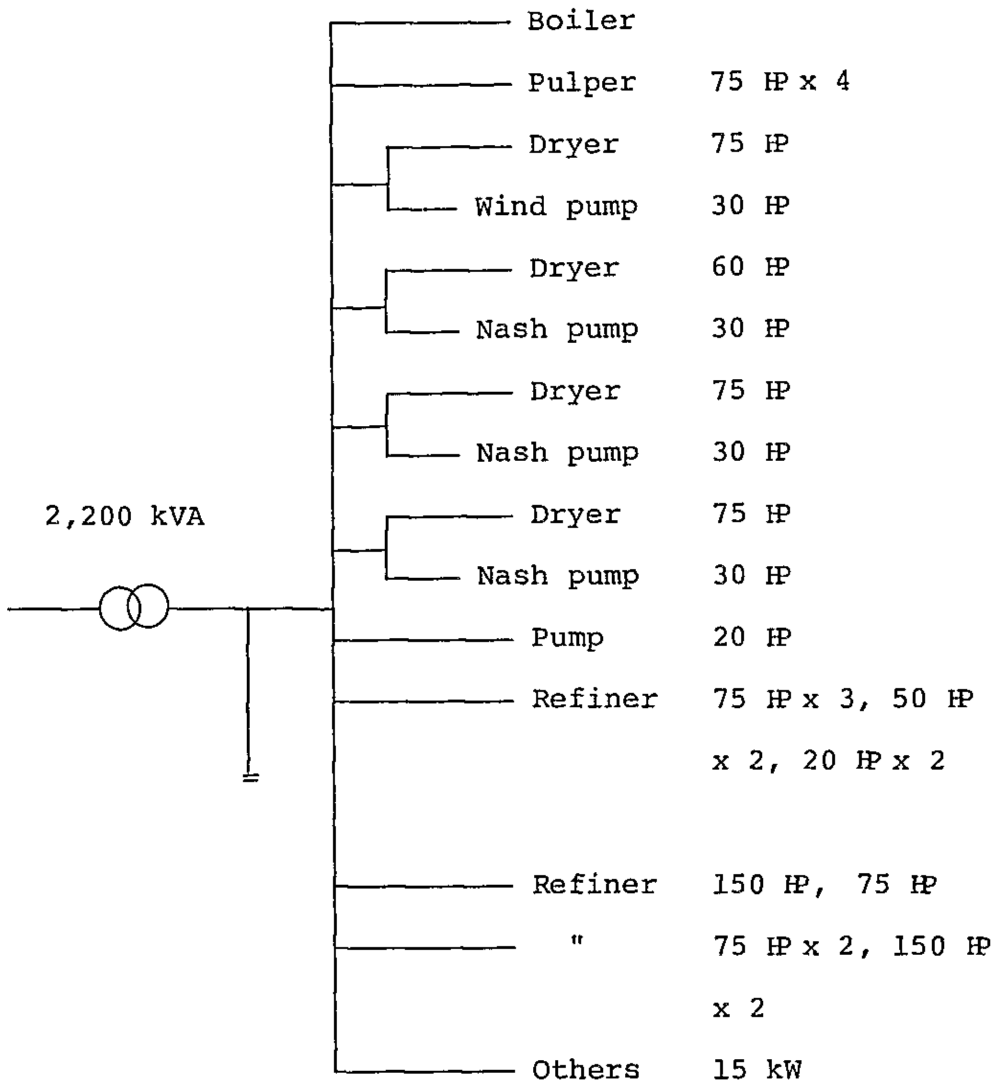
A further energy-saving effect can be obtained if the temperature of boiler feed water is raised by feeding the boiler directly by condensate pump with the water at high pressure.

7. State of Electric Power Consumption

(1) The principal data relating to power consumption are as follows:

Power company	-	PEA
Peak demand	-	Not available
Electric power used	-	585,000 kWh/m
Load factor	-	Not available
Penalty	-	None
Power factor	-	98%
Main transformers	-	2,200 kVA, 24 kV/400 V

(2) One-line diagram



Since a 4-line paper-making machine is operated on a ground-based 2,200 kVA transformer on the factory premises, each line has a small capacity.

No one-line diagrams have been made out. No employees in the instrument room were able to answer our questions as to which amperemeter indicated which electric current. We made examinations and worked out a one-line diagram. Electric power controllers are advised to work on it to make out a perfect diagram.

8. Problems in Electric Power Control and Potential Solutions

(1) Power factor

The power factor was 98% for a lag and 97% for a lead. When no condenser was connected, the power factor stood at 54 - 77%.

The 97% leading power factor is due to a bad relay resulting in an excessive application of the condenser. Any lead in the power factor would be undesirable as it means so much condenser loss and a higher voltage. To improve the 97% leading power factor is to become a 97% lagging power factor, the capacity of the condenser to be inserted will be as follows:

Condenser capacity at time of 97% leading power factor	644.5 kVr
Condenser capacity at time of 97% lagging power factor	590 kVr

The condenser capacity is 235.7 kVr in excess. The condenser loss is 0.2% of power. Given that operation with a leading power factor lasts 10 hours a day, the loss increases by 1,608 kWh/y annually. If operation is conducted with a 97% lagging power factor, there will be so much saving. Bad relays should be repaired immediately.

(2) Operation of motors

As shown in the following table, two large motors were found to be operating with a load 50% or more lower than for the rated current. A lighter load on the motors meant a lower power factor. Small motors of up to 20 HP could be considered to be in light load operation.

Motors should be checked periodically to record electric currents. It is necessary to improve the mode of doing work with machines and equipment if they are long in light load operation.

<u>Principal Motors in Operation</u>

Used for:	Output HP	Rated current Ⓐ	Load current Ⓑ	Ⓑ/Ⓐ %	Power factor %
Pulper	75	110 A	82 A	74.5	83
"	75	108	63	58.3	77
No.1 dryer	75	103	52	50.5	70
No.3 dryer	75	103	64	62.1	79
No.4 dryer	60	83	16	19.3	10
No.3 line Nash pump	30	44	28	63.6	75
No.4 line Nash pump	30	42	11	26.2	10
Refiner	150	229	155	67.7	86
"	75	100	100	100	88

(4) Lighting

We found transparent slates used for the factory roof with room lights turned off in the second floor. But we saw 4 fluorescent lights turned on in the daytime. We were told that they could not be turned off as they were connected by a common switch to the first floor. Switches should be separated. Separate switches would save 584 kWh/y of electricity annually if lights were on for 12 hours a day.

If energy-saving white light lamps are used instead of daylight lamps, electricity will be saved by 10%. As the illuminating power is 14 kW, this will save 3,066 kWh/y on it.

9. Summary

The above remedial measures, if actually taken, will bring about energy-saving effects as shown below:

Measures	Potential energy saving		Rate (%)
Steam reduction for pulper temperature adjustment	41 kl/y	(fuel oil)	2
Improvement of refining, screening and operation	41	(fuel oil)	2
Increasing pressure	102	(fuel oil)	5
Dryer hood improvement	41	(fuel oil)	2

Boiler air ratio improvement	55	(fuel oil)	3
Insulation improvement	27	(fuel oil)	1
Steam leakage repair	5	(fuel oil)	-
Subtotal	312		15
Condenser relay repair	1,608 kWh/y	(electricity)	1
Lighting improvement	3,650 kWh/y	(electricity)	1