6.3 Results of the Study at Abkouh Sugar Company

6.3.1 Outline of the plant

(1) Plant name

Abkouh Sugar Company

(2) Plant address

Quchan Old Way, Mashad

(3) Number of employees

250 (excluding seasonal workers)
Including 10 process engineers
1 thermal engineer
2 electrical engineers

(4) Major products

Beet sugar

(5) Production capacity

Sugar	: 20,000 t/y
Cone sugar	: 10,000 t/y
Dry pulp for cattle feed	: 15,000 t/y
Press pulp for cattle feed	: 25,000 t/y
Molasses for fermentation material	: 2,000 t/y
Crystallized sugar	: Still on the trial-manufacturing stage

(6) Production process

Beet is stored in the open silo, and then sent with approximately ten times more water to the washer on the fifth stage.

For the diffusion, the BMA system is employed. Pulp is subjected to hot air drying in parallel flow. The leached thin juice has a sediment removed by the Oliver filter after lime treatment, carbonator and thickener. Then it is again filtered after carbonation. There is a softener provided, which is at present not in use. The filtrate, i.e., thin juice, is made into standard syrup with the second sugar solved.

It is then concentrated by the quadruple-effect evaporater. This plant has no bleaching process using ion exchange resin. However, bleaching is conducted by using activated carbon only for producing cone sugar.

Only the first sugar makes a product at the crystallizer. A high-speed centrifugal separator is partly employed.

The molasses from the third pan is mixed with pulp, etc. to be used for the cattle feed, and besides the sugar is recovered by Steffen method.

In the case of cone sugar, sugar is melted, concentrated, centrifuged for deaerating, and dried to make a product.

Since this plant has no farm of its own, it is difficult to get an even amount of beet according to the production schedule. The silo is now being enlarged, but even this can hardly prevent the sugar quality from denaturing, making it difficult to improve the yield.

The production period is October to March, with 80 ~ 140 annual operating days.

Figure 6.3.1 shows the process flow.

(7) History of the plant

This plant was established 60 years ago, and after a capital transfer it is now owned and managed by a religeous corporation.

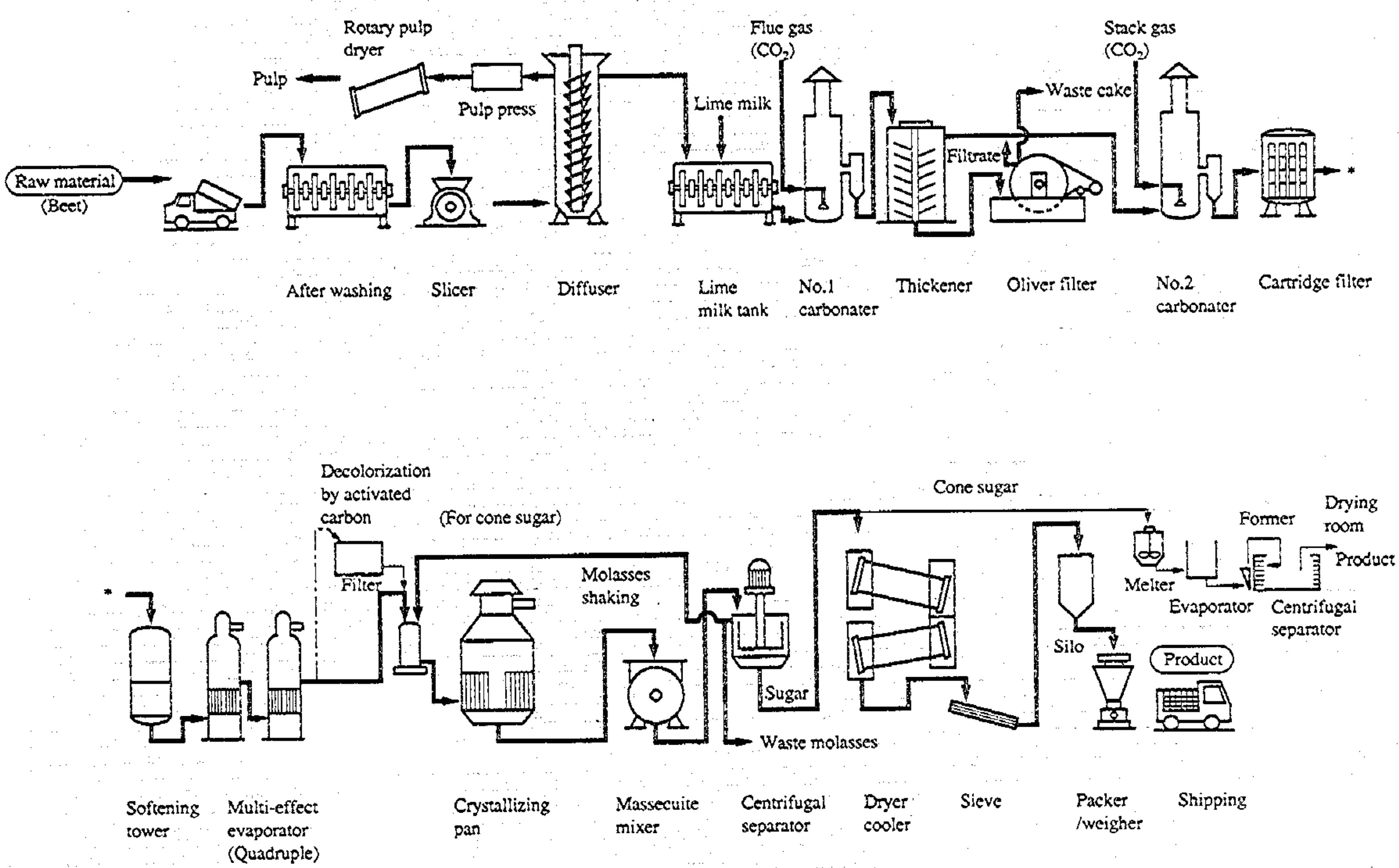
The current main production line, which was additionally installed 30 years ago, has a beet treatment capacity of 2,500 t/d (24 h), which is planned to be finally increased to 4,000 t/d.

In terms of profit, this company ranks among the top ten beet sugar companies of 2,000 t/d class within 35 companies.

For energy, the company is now switching boiler fuel to natural gas, and a new boiler is now under additional construction. For the fuel used for calcining the lime, coke was switched to heavy oil 9 years ago.

This company takes a positive action in investment necessary for improvements of equipment such as adoption of BMA Company's vertical type diffuser in addition to the horizontal type diffuser. This greatly contributes to the establishment of the present production system.

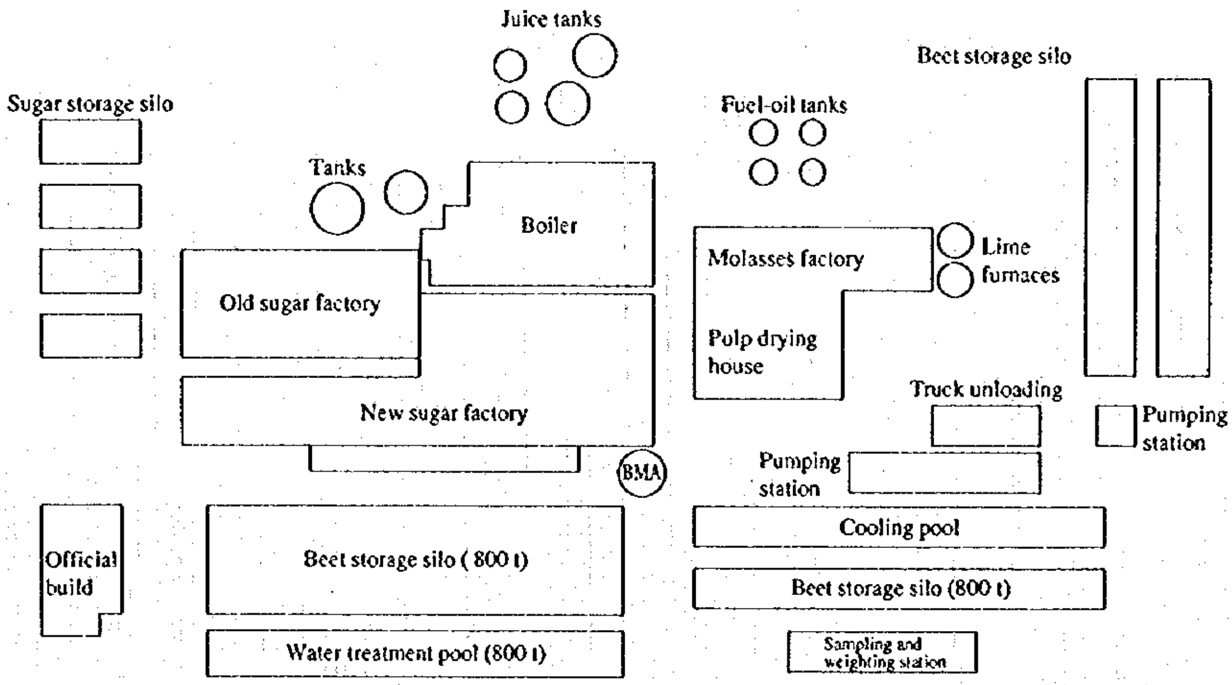
Figure 6.3.1 Process Flow



(8) Plant layout

Figure 6.3.2 shows the plant layout.

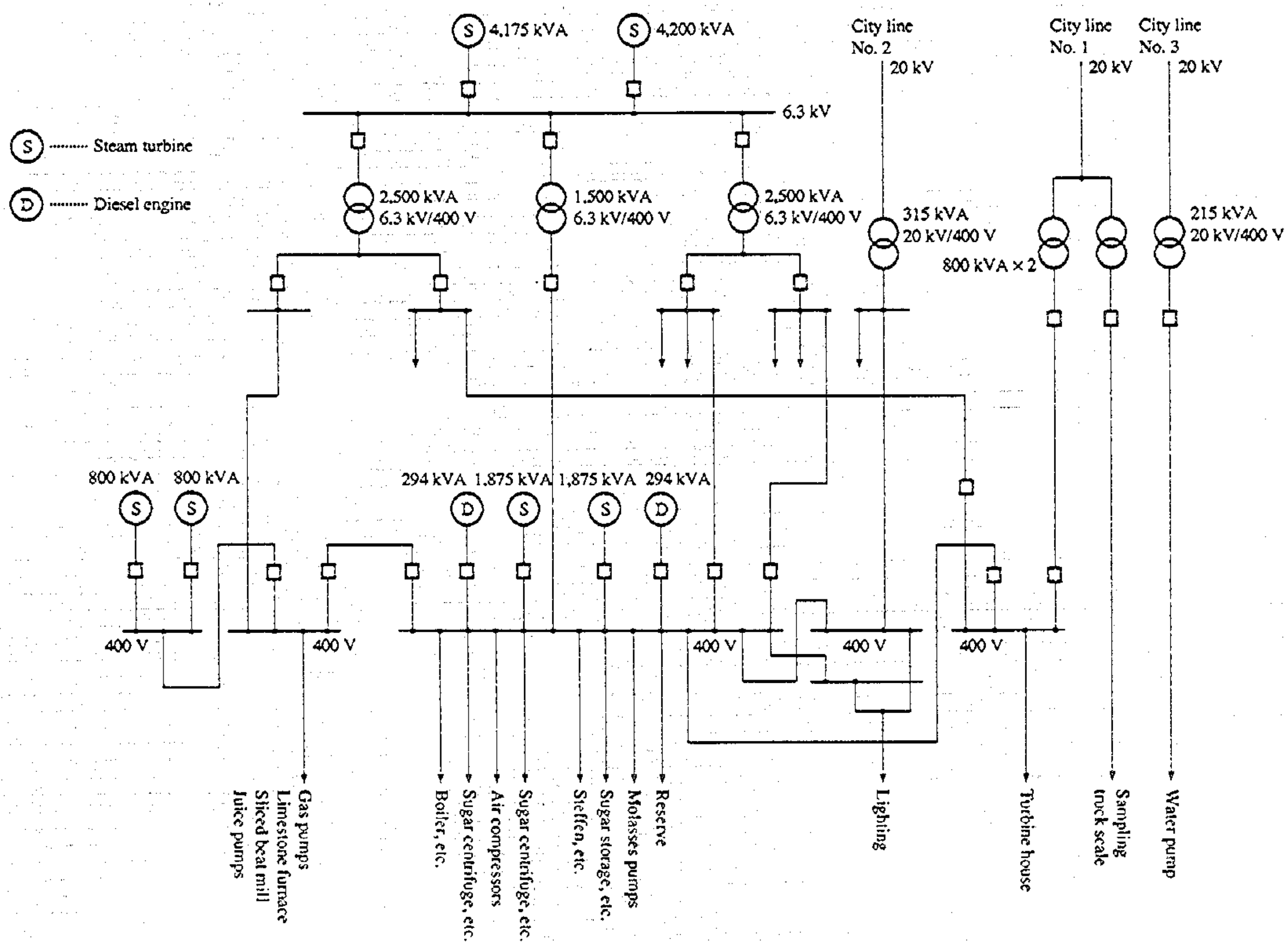
Figure 6.3.2 Plant Layout



(9) One line diagram

Figure 6.3.3 shows electric power one line diagram.

Figure 6.3.3 One Line Diagram



(10) Outline of major equipment

Table 6.3.1 shows the outline of major equipment.

Table 6.3.1 Major Equipment

Name	Number	Specification
Beet Silo	4	800 t × 4
	30	1,500 t × 30
Diffuser	2	BMA Diffuser 2,500 t/d, Horizontal Diffuser 2,500 t/d
Carbonater	1	2,500 φ, 50 m³
Filter	3	Rotary Type × 3
Carbonater	2	2,500 φ, 50 m³
Filter	2	GPL-Press Filter to Carbonate 64 m² unit × 2
Standard Syrup Tank	1	20,000 L
Evaporator	1	Quadruple-effect evaporator
Boiling Crystal Pan	6	40 t/Batch, Vacuum 55-60 mmHg, 1 spare
Centrifugal Separator	11	1,000 RPM
Sugar Dryer, Cooler	1	Rotary 85 ~ 90 °C
Packer	1	50,100 kg/bag
Pulp Dryer	1	Rotary, Hot Air
Steam Tank	1	2 m³
Cone Sugar Plant	1	Evaporator (quadruple), Centrifugar Dryer, etc.
Steffen Plant	1	
Steam Turbine Generator	2	Back-pressure turbine 3,500 kW, 6.3 kV, Steam pressure 33/2.5 kg/cm² (G)
	2	1,500 kW, 400 V, Steam pressure 18/2.5 kg/cm² (G)
	2	560 kW, 400 V, Steam pressure 18/2.5 kg/cm² (G)

(11) Energy price

Demand charge: 1,700 Rial/kW
Energy charge : 45 Rial/kWh

(12) Study period

a. Preliminary study: October 21, 1995

b. Plenary study: August 24 to 26, 1996

(13) Members of the study group

a. JICA team

Leader	:	Mitsuo Iguchi (Preliminary study)
Leader	:	Norio Fukushima
Process management technology	:	Shiro Honda
Heat management technology	:	Jiro Konishi
Heat management technology	:	Takashige Taniguchi
Electricity management technology	:	Kazuo Usui
Economic evaluation	:	Shigeaki Kato (Preliminary study)

b. PBO team

Energy conservation	:	Mr. Mazhari
Micro level energy management	:	Mr. Mianji
Macro level energy management	:	Mr. Azizi (Preliminary study)
Macro level energy management	:	Mr. Moosavi (Preliminary study)
Macro level energy management	:	Mr. Tohangchi
Consulting Office for Sugar Industries	:	Mr. Pouryousefi (Preliminary study)

(14) Interviewees

Mr. Ali Reza Ashraf	:	General Director (Preliminary study)
Mr. Beyhaghi	:	Technical Manager
Mr. Taghavi	:	General Manager of the Factory (Preliminary study)
Mr. Ehsani	:	Deputy Manager of the Factory
Mr. Shademan	:	Electrical and Automation Manager
Mr. Haddadian	:	Boiler Manager
Mr. Razavi	:	Electrical Engineer
Mr. Marvi	:	Process Engineer

6.3.2 Situation of Energy Consumption

(1) Trend of production, energy consumption and energy intensity

a. Production

Table 6.3.2 shows the trend of production.

Table 6.3.2 Production

		1989*	1990	1991	1992	1993	1994	1995
Sugar	t	9,980	8,805	14,755	24,021	21,532	15,787	13,477
Cone Sugar	t	7,826	8,018	11,814	11,807	12,355	10,671	9,956
Total	t	17,806	16,823	26,569	35,828	33,887	26,458	23,433

*: October 1989 to March 1990: This period (from October to March in the next year) also applies to the other years.

b. Energy consumption

Table 6.3.3 shows the trend of energy consumption.

Table 6.3.3 Energy Consumption

		1989**	1990	1991	1992	1993	1994	1995
Fuel oil	L			6,507,798	6,213,494			2,927,557
Natural gas	m^3	14,408,150	14,629,857	19,750,794	27,510,308	20,694,392	21,431,219	19,447,565
Electricity	MWh							12,723
Electricity*	MWh	9,387	9,208	12,874	17,076	16,020	18,000	10,785

Remark: Electricity marked with * indicates that by in-house generator.

**: October 1989 to March 1990: This period (from October to March in the next year) also applies to the other years.

c. Energy intensity

Table 6.3.4 shows the trend of fuel oil and electricity intensity.

Table 6.3.4 Fuel Oil and Electricity Intensity (1995)

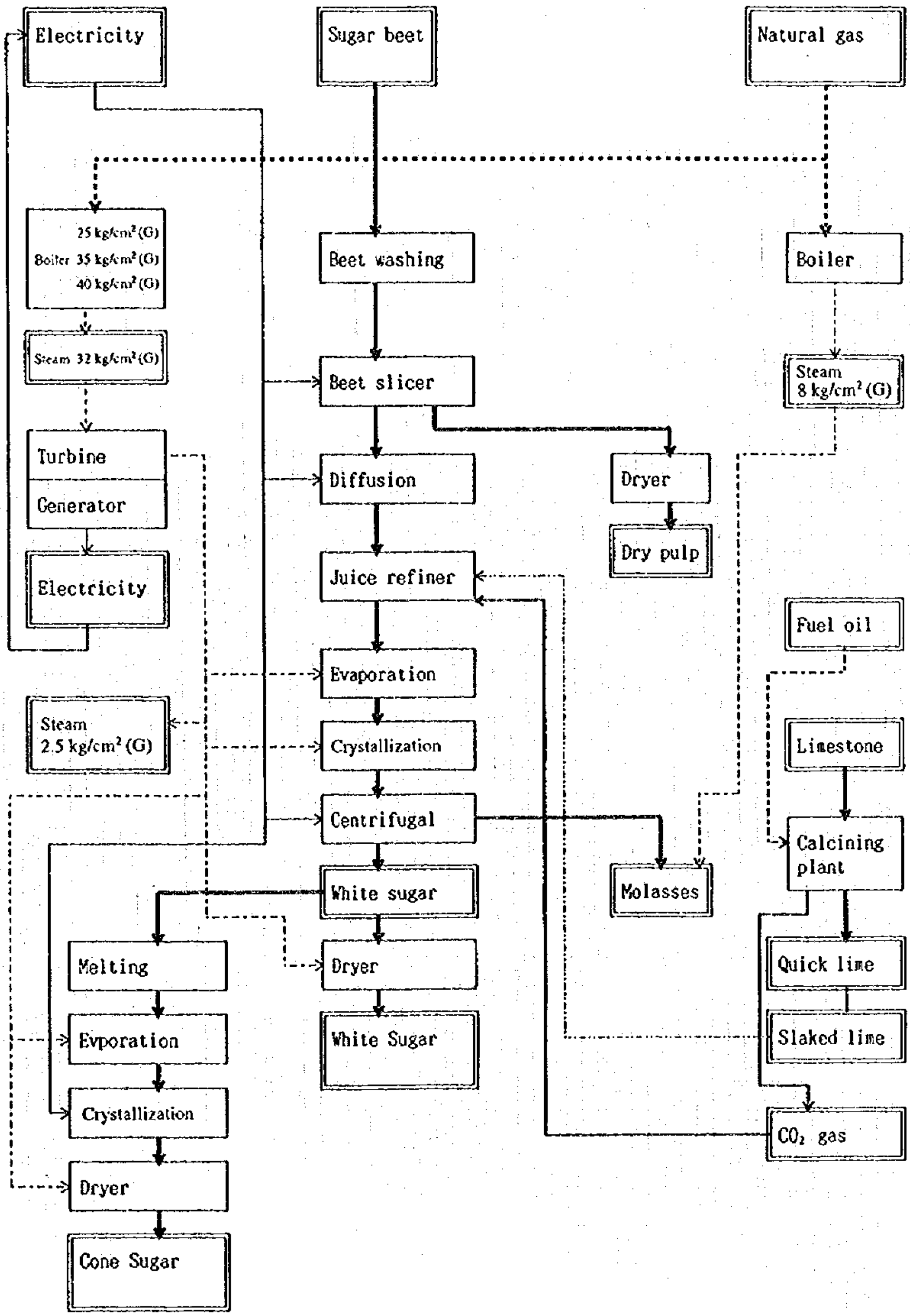
Type of Fuel	Unit	Intensity
Fuel	Mcal/t	9,060 (Total) 8,664 (except power generation)
Electricity	kWh/t	543

Note: $9{,}060 - \frac{460 \times 860}{1{,}000} = 8{,}664$

d. Energy flow

Figure 6.3.4 shows the energy flow.

Figure 6.3.4 Energy Flow



e. Outline of plant electrical equipment

The electric power for this plant is supplied by the private power generator and purchased power system. They are not in parallel operation but separately provided.

The purchased electric power is supplied at 20 kV, and the maximum demand is 1,550 kW. For private power generation, this company has back-pressure turbine generators of 7,900 kW in total.

The ratio of the privately generated power and the purchased power in the supplied electric power is approximately 3:1.

Table 6.3.5 shows the power demand situation during the plant operating. About 85 % of the electric power for the plant is supplied by the privare power generator, while 15 % by the purchased power from the external line. No detailed data on power factor and load breakdown was obtained because of the plant's shutdown.

Table 6.3.5 Electric Power Supply and Demand

Month	No. 2 Generator (kW)	No. 3 Generator (kW)	No. 7 Generator (kW)	Generator Total (kW)	Purchased Power (kW)	Factory Total (kW)
1995.10	649.7	657.6	928.0	2,235.3	289.0	2,524.3
1995.11	712.6	712.6	1,342.9	2,768.1	312.2	3,080.3
1995.12	740.6	740.6	1,345.9	2,827.1	381.6	3,208.7
1996.01	599.4	599.4	1,155.1	2,353.9	293.5	2,647.4
1996.02	318.5	172.9	109.0	600.4	661.4	1,261.8
Total	3,020.8	2,883.1	4,880.9	10,784.8	1,937.7	12,722.5
Average	918.4	941.0	1,662.6	–	–	–
Utilization factor	0.612	0.627	0.475			

Note: Since the purchaced electricity is measured according to the Islamic era, it differs more or less from that by the Christian era.

6.3.3 Situation of Energy Management

(1) Setting the target for energy conservation

To start energy conservation efforts, the top management of the company must define energy conservation as one of major management targets, demonstrating serious attitude and enthusiasm for energy conservation to the employees. This will convince the employees that making efforts for energy conservation will conform to the policy of the company and will motivate them for positive efforts. When policy is shown by these top management, mere abstract instruction for energy conservation is not sufficient; concrete target values and the deadline for achieving the goal must be shown to the workers. In response to these instructions, each section of the factory should set up the concrete targets for individual items which can be taken charge of within the scope of the responsibility, so that the overall target can be achieved. Only after the target has been set, concrete action plans to achieve the target can be worked out, including study of various approaches, preparation of the programs, and assignment of the works. However, setting the target requires correct information on the current energy consumption in the factory.

This factory, where no first priority is placed on energy, has no specific target set up yet. Before setting up the target, it is necessary to have a correct understanding of the energy consumption of the factory.

(2) Systematic actions

No close systematic communication can be seen between the departments.

An energy conservation committee should be set up so that excellent engineers representative of each department take the lead in proceeding with measures for energy and environmental conservation.

(3) Data-based management

Data-based management is necessary to implement energy conservation activities. Quality control is performed well in the analysis room, but there are inadequacies found on the utility record log regarding the details of the processes.

Flowmeters for water and steam used for each process need to be installed. The installation of these meters can increase the accuracy of the energy conservation plan, quantify problems and ensure the evaluation of the improvement effects particularly for the crystallizer, it is expected that measurement of steam flow and installation of water flow meter will allow the rational implementation of process management.

(4) Education of employees

Energy conservation should be implemented by all the employees in the top-down way, and it requires the cooperation of staff.

This plant, which takes a positive attitude toward the development of a new product, has an excellent manager and engineers with abundant experience. Therefore it is advisable to educate and train employees in terms of self management to achieve their own target.

It is noteworthy that 10 plants in the province have held joint seminars for these 18 years to exchange technical data and organized joint research institutes, thus making every effort to improve their technique.

They employ the same operators every year, who are expected to keep their technological level.

(5) Equipment management

Equipment is relatively well maintained because they have plenty of time for maintenance during the non-manufacturing period and also because exchangers, etc. requires disassembly cleaning since they are more liable to clogging for the peculiarity of the process.

The crystallizer comes short in capacity, and its additional installation is now being considered.

Iron rust is observed to occur heavily on the heat-transfer surface of the crystallizer. Hence some improvement measures should be taken to cope with corrosion, etc. in terms of material quality.

6.3.4 Problems in the Use of Energy and the Countermeasures

(1) Comparison with a Japanese Excellent Plant

Table 6.3.6 shows the comparison of energy intensity between this plant and a Japanese excellent plant.

Table 6.3.6 Comparison of Energy Intensity

	Abkouh	Japan
Scale	23,433 t/y	same as Abkouh
Fuel intensity	8,664 Mcal/t	4,794 Mcal/t
Electricity intensity	543 kWh/t	120 kWh/t
Yeild of production	12.8 %	16.6 %
Process		
Cone sugar process	available	not available
Bleaching process using Ion exchange resin	not available	available
Equipment		
Vacuum pan with an agitator	not available	available

On the basis of production 23,433 t/y in 1995, fuel intensity is 8,664 Mcal/t, and electricity intensity is 543 kWh/t. These are by far higher than the energy intensity of a Japanese excellent beet plant of the same scale, i.e. fuel intensity of 4,794 Mcal/t, and electricity intensity of 120 kWh/t.

For the scale, there are plants having the production scale of about 3,000 t/d in Japan, but comparison was made with an assumed plant of the same scale.

The product color of the Japanese excellent plant is whiter than that of this plant.

Since the Japanese excellent plant is located in the cold area, the raw beet storage period is short, and besides, ion exchange resin treatment was performed, making the purification degree of the juice higher. These factors contribute to the high yield of the Japanese plant.

	Abkouh	Japanese plant	Difference
Yield	12.8 %	16.6 %	30 %

As easily supposed, in the Japanese plant the facilities are generally arranged compactly and the electricity loss and heat loss are remarkably low, thus leading to energy conservation. The factors to be considered next include the differences in process, equipment and operation management.

As for the process, a large amount of steam and electricity is consumed to evaporate and dry the water in Abhouh plant because of the cone sugar process, which is not provided in the Japanese plant. The actual result in 1995 shows that the production of beet sugar accounts for 58.5 %, while that of cone sugar occupies 41.5 %. The cone sugar is, after being remelt, boiled down, put in the mold at Pol 92, centrifuged, and dried to be made into a product. Assuming that the water content of 7 % is evaporated, even the increment in the fuel intensity for this evaporation alone is as large as is expressed in the following formula.

$$0.415 \times \left(\frac{1}{0.93} - 1 \right) \times 640 \times \frac{1}{0.8} \times 1,000 = 25 \text{ Mcal/t}$$

This also increases electricity intensity.

While ion exchange treatment is performed in the Japanese plant, it is not conducted in this plant.

As for the equipment, the crystallizer pan in the Japanese plant is equipped with an agitator, which is not provided in this plant.

As for the management, an energy conservation committee is set up in the Japanese plant to enhance and improve the management for heat insulation and steam trap. Moreover, automatic control and remote control of the crystallizer pan operation is conducted.

(2) Material balance of a crystallizer pan

Figure 6.3.5 shows the result of calculating the material balance of sugar and water for 1,000 t of products including those from the evaporator to the crystallizer pan. Since detailed operation data was not available, some assumed preconditions were used. Therefore, there may be some points different from the actual situation.

The amount of water addition is assumed as constant; 201 t for the 1st pan, 121 t for the 2nd pan and 129 t for the 3rd pan. The steam amount required to evaporate 1 t of water is assumed at 0.33 t for the evaporator, 1.25 t for the crystallizer pan and 3.3 t for the dryer.

Changes in the water evaporation amount and the required steam amount resulting from some changes in the conditions were calculated based on Figure 6.3.5.

Figure 6.3.6 shows a 5 % increase in the yield for each crystallizer pan by means of increasing the purification degree, etc. Steam consumption can be reduced by 4 % compared with the case in Figure 6.3.5. Similarly, improving the second sugar product in the 2nd pan and blending it in the 1st sugar to make a product will allow steam consumption to be reduced by 11 % though the amount of water addition is the same as shown in Figure 6.3.7.

Furthermore, decreasing the number of batches by the reduction of treated liquid is expected to increase the productivity, thus leading to energy conservation.

Figure 6.3.5 Material Flow of Boiling Pan (Case 1)

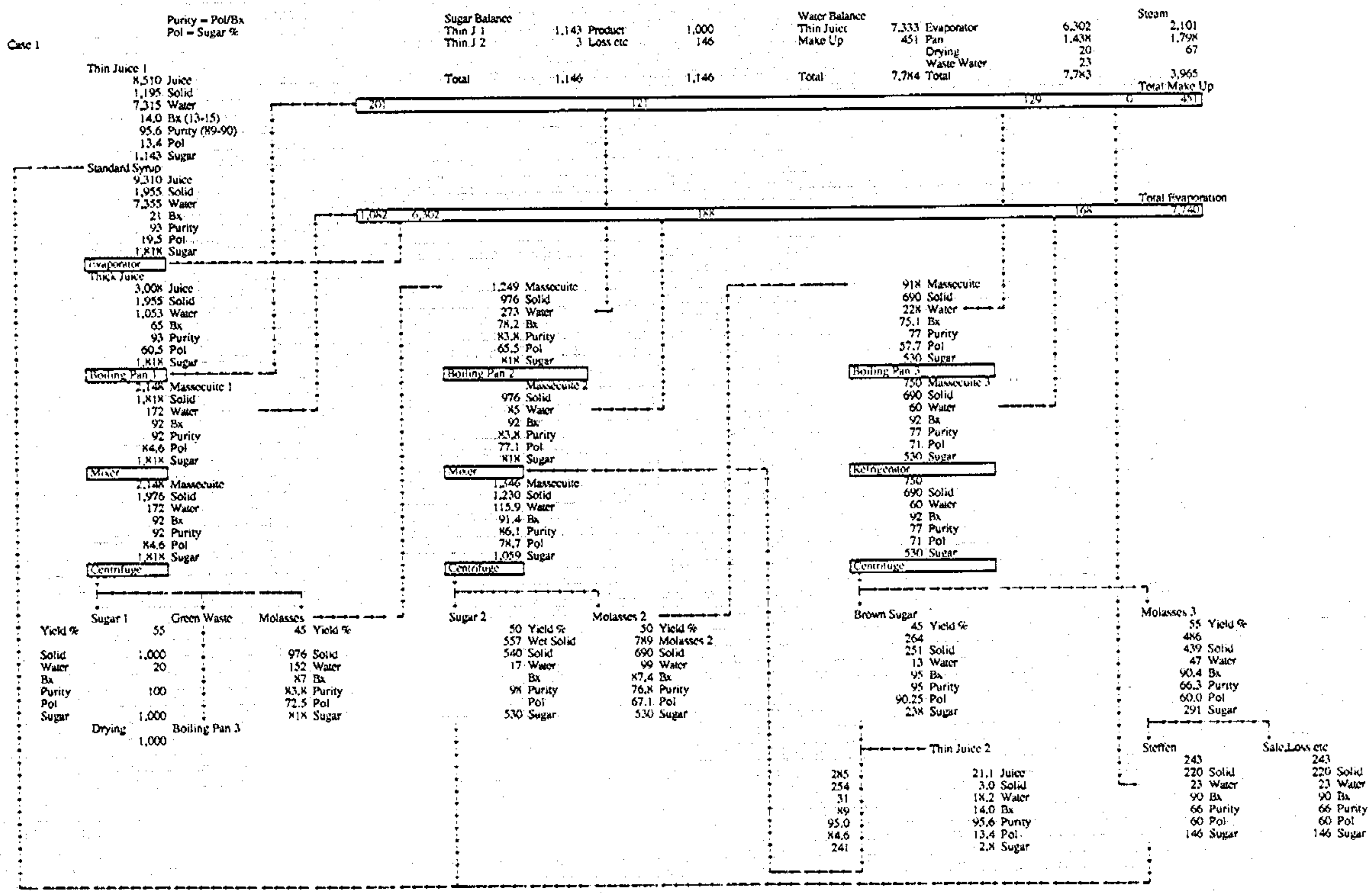


Figure 6.3.6 Material Flow of Boiling Pan (Case 2)

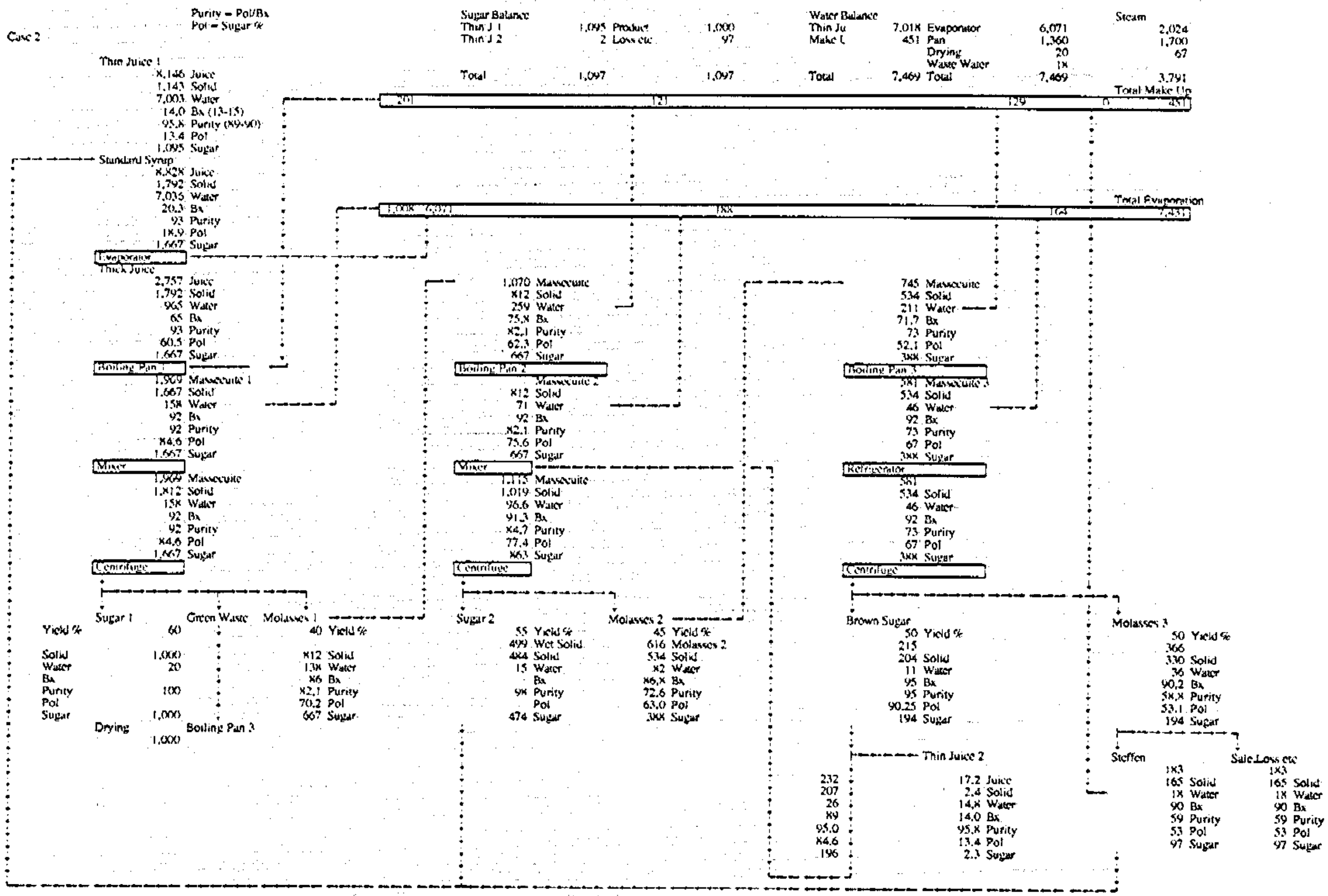
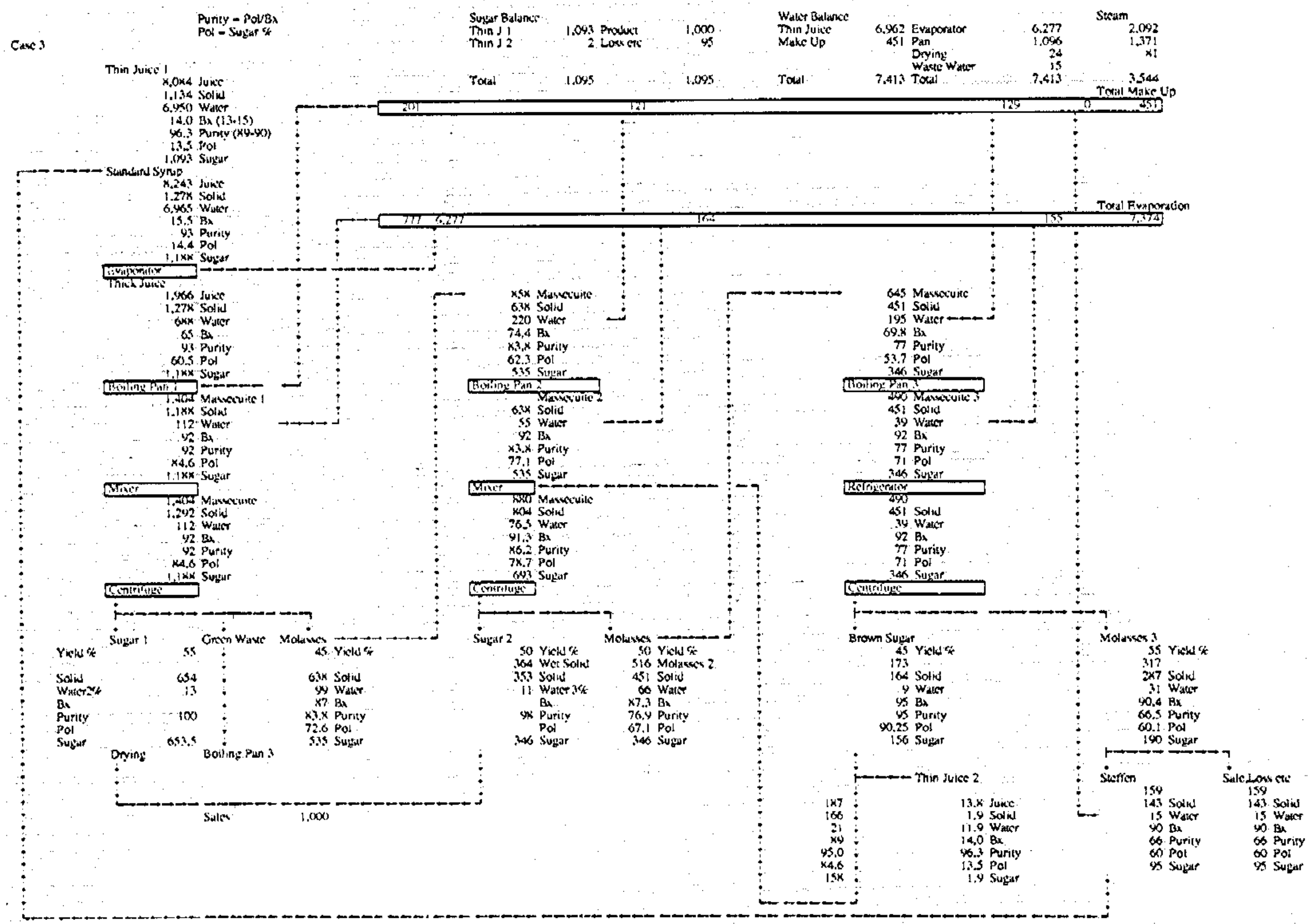


Figure 6.3.7 Material Flow of Boiling Pan (Case 3)



(3) Improvement of sugar quality by the use of ion exchange resin and increasing the efficiency of the boiling system

The evaporator and the crystallizer pan are both easy to form scales, and besides, the sugar boiling time in the crystallizer pan is coming longer. A spare evaporator is available and cleaning is conducted in the sugar manufacturing period, but the efficiency decreases during the period before cleaning.

A softening tower using cation exchange resin is provided, but now it remains usused.

The thin juice extracted from beet contains calcium ion as well as coloring matters and salt. Therefore, if this juice is directly concentrated, scale will occur on the evaporator, thus remarkably reducing the thermal efficiency. Hence, the necessary process for the beet sugar plant to prevent this is to install a juice softening equipment using a strong acid sodium type ion exchange resin before the evaporator. Here the calcium ion in the juice is replaced by sodium ion through a softening type ion exchange resin.

This ion exchange treatment allows reducing the concentration time in the evaporator and also increasing the Bx value by 5 compared with the conventional process. At the same time this treatment makes it more difficult for scales to form, resulting in the reduction of the sugar boiling time and also energy conservation.

The use of a softening equipment requires one more tower, that is, two towers for the regeneration of resin.

As the result of this measure, steam consumption is expected to be reduced by 5 %, including the effect on the crystallizing pan.

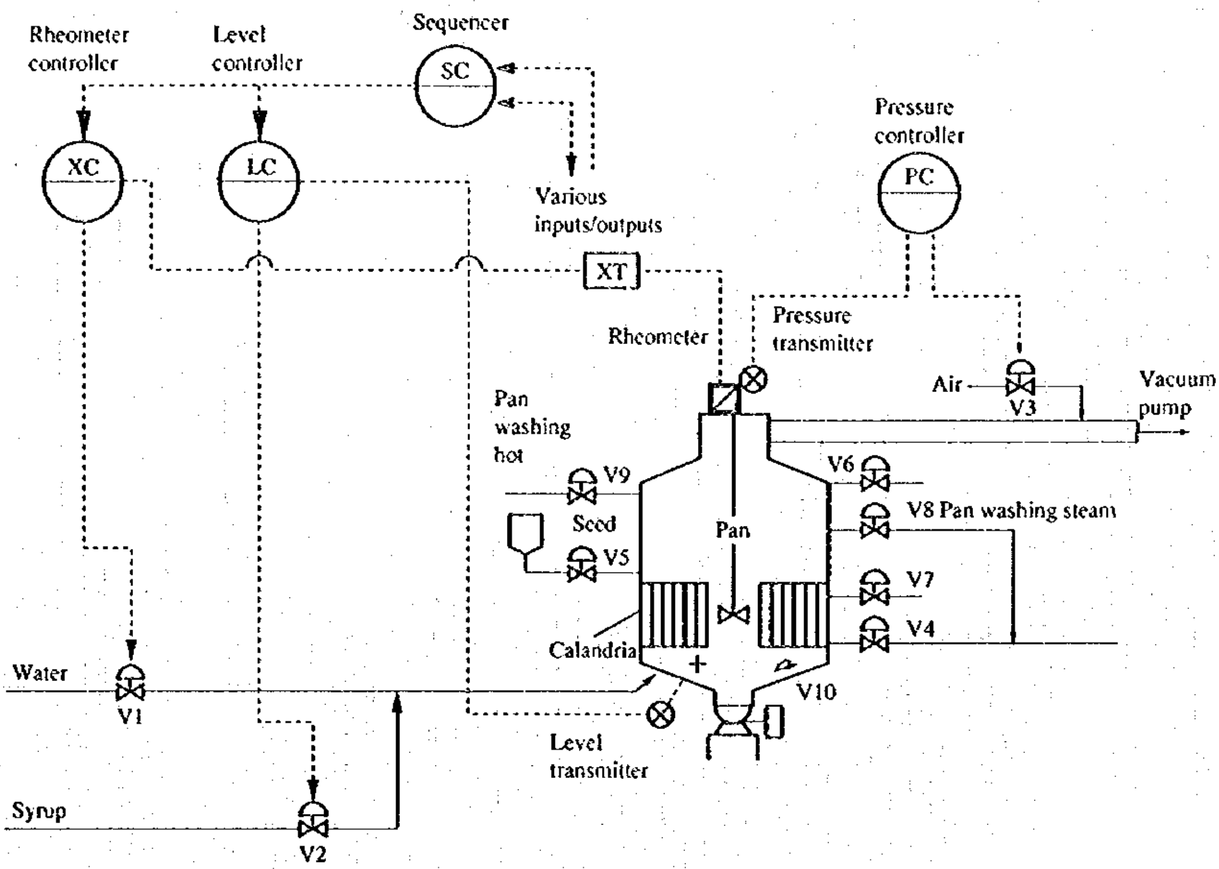
(4) Reduction of the sugar boiling time through automatic control of the crystallizer pan and improvement of the vacuum

At present, the sugar boiling time is 2.5 hours for the first sugar, 3.5 hours for the second sugar, and 10 hours for the third sugar. In the crystallizer pan, particularly the boiling time for the third sugar should be reduced to 7 h/batch as in Japanese plants. The crystallizer pan has no agitator.

In order to reduce the sugar boiling time, it is advisable to install an agitator, adopt an automatic control system and improve the vacuum. In recent plants, the crystallizing pan has been equipped with an agitator, and besides there has become available such a control equipment that allows a proper control of concentration by a combined use of a mobility controller and a level controller.

Figure 6.3.8 shows a general automatic control system.

Figure 6.3.8 Automatical Control System Diagram



The product grain size can be made uniform, and water addition can be reduced by automatically controlling the supply of the syrup and water while measuring the mobility of the syrup in the crystallizing pan so as to obtain a proper crystal concentration in the liquor being boiled.

The reduction effects of water addition are as follows:

First sugar massecuite	4 kL → 2 kL/batch
Second sugar massecuite	6 kL → 3 kL/batch
Third sugar massecuite	10 kL → 5 kL/batch

In the Japanese plant example, where an agitator is installed on the third sugar crystallizing pan, the sugar boiling time is reduced to 7 hours from 10 hours.

It is vitally important for the pan boiling to control the concentration of the syrup in the pan during boiling. Excessive supersaturation of the mother liquor surrounding a base crystal causes secondary crystallization to occur, interfering with the molasses separating operation. Besides, crystal sticking together form false crystal, and make the crystal size uneven, thus degrading the product value.

Moreover, boiling takes too much time in the case of the vacuum of 680 to 700 mg in the crystallizer. The vacuum should be increased to 700 to 750 mmHg by means of separating a vacuum system from each pan and keeping the cooling water temperature of the barometric condenser low.

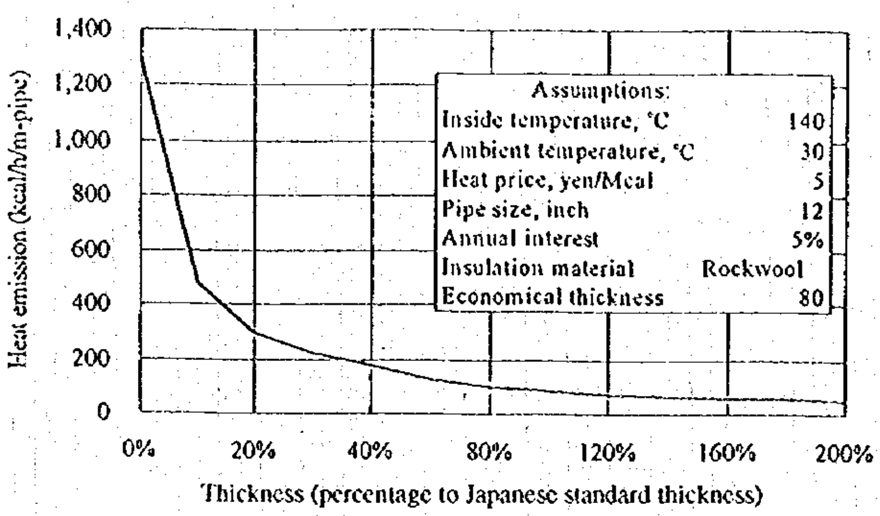
The above-mentioned measures can reduce the steam consumption by 10 %

(5) Heat Insulation

In this plant, heat insulation is provided to the steam pipe, but it is not provided to the attached valves. By providing heat insulation to these bare parts, heat radiation loss will remarkably decrease as the heat insulation thickness increases.

Figure 6.3.9 shows the calculation example.

Figure 6.3.9 Insulation Thickness and Heat Emission (an example)



Next, Table 6.3.7 and Table 6.3.8 show the result of calculating the amount of heat loss from the steam valves on the basis of their assumed number.

Table 6.3.7 Assumed Number of Bare Valves

No.	Size (Pipe diameter) Noinal (mm)	Size (Pipe diameter) Actual (mm)	Equivalent Length (m)	Number of Valves	Length for calculation (m)
1	300	318.5	1.91	6	11.4
2	250	267.4	1.76	20	35.3
3	200	216.3	1.68	60	100.8
4	150	165.2	1.50	60	90.0
5	100	114.3	1.27	40	50.8
6	80	89.1	1.25	100	125.0

Table 6.3.8 Calculated Heat Emission from Bare Valve Surface

No.	Temperature Ambient (°C)	Temperature Surface (°C)	Emissivity	Pipe Diameter (m)	Area Length (m)	Heat Transfer Coefficient Convection (kcal/m·h·°C)	Heat Transfer Coefficient Radiation (kcal/m·h·°C)	Unit Heat (kcal/h/m)	Total heat (kcal/h)
1	30	100	0.9	0.319	11.4	4.493	6.866	796	9,096
2	30	110	0.9	0.267	35.3	4.643	7.195	796	28,045
3	30	130	0.9	0.216	100.8	4.904	7.893	870	87,653
4	30	130	0.9	0.165	90.0	4.904	7.893	664	59,773
5	30	110	0.9	0.114	50.8	4.643	7.195	340	17,276
6	30	110	0.9	0.089	125.0	4.643	7.195	265	33,137
Sub total									234,980
Bare pipes around these valves are assumed to be 50 %.									117,490
Grand total									352,470

The surface area of the valves, which shape is complicated, is equivalent to the surface area 1.2 to 3 times as large as the straight pipe of the same diameter. This equivalent length is used for heat loss calculation. Table 6.3.9 shows the straight pipe equivalent length for the steam valves.

Table 6.3.9 Equivalent Length of Valves

Nominal Size Diameter (mm)	Actual Size Diameter (mm)	Equivalent Length (m/piece of valve) F-G 10	F-G 20	F-S 10	F-S 20
25	34.0	1.22	1.21	1.15	1.32
50	60.5	1.11	1.28	1.22	1.53
80	89.1	1.25	1.56	1.31	1.63
100	114.3	1.27	1.58	1.20	1.50
150	165.2	1.50	1.78	1.35	1.92
200	216.3	1.68	1.87	1.52	
250	267.4	1.76	2.14		
300	318.5	1.91	2.33		

Symbols: F-G: Flange ball valve
F-S: Flange sluice valve
CV: Control valve
F: Flange
10 k: 10 kg/cm^2 (G) rating
20 k: 20 kg/cm^2 (G) rating

The boiler fuel reduction amount by heat insulation obtained from the above-mentioned heat radiation loss will be 1,046 Gcal per year (assuming that the heat radiation reduction rate is 90 %, the number of annual operating days is 110 days, and the boiler efficiency is 80 %). This effect is equivalent to 0.5 t/h of steam.

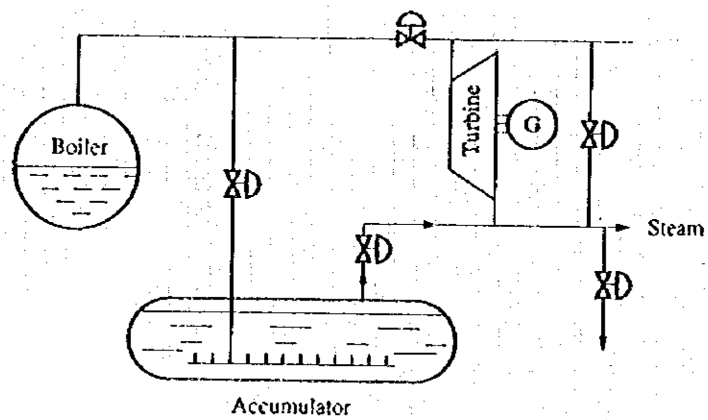
(6) Installation of an accumulator

In this sugar manufacturing process, the required amount of steam fluctuates by time, since the operation of the evaporator and the vacuum pan is of batch type.

On the other hand, the unbalance between power demand and steam demand will have to be, in some cases, absorbed by steam release because the power system is not in parallel with the commercial power source. For this purpose, there is a high pressure steam tank installed, which volume is 2 m^3. Generally, a steam accumulator is, in many cases, provided in the industrial field to absorb the fluctuation in the steam demand. Also in Japanese industrial field including the sugar manufacturing industry, many accumulators are in use.

The accumulator is a pressure vessel containing the saturated hot water in its inside, where steam is stored in the form of saturated water when it is excessive. On the other hand, when steam amount becomes insufficient, steam generates from the saturated water in the way of self-evaporation when the pressure drops. Hence, in order to absorb the fluctuation, steam pressure should have some allowance, which applies similarly to the steam tank. Figure 6.3.10 shows an example of steam accumulator.

Figure 6.3.10 Steam Accumulator System



Steam generation amount, i.e., the steam amount stored in the steam accumulator can be calculated based on the accumulator pressure (initial pressure and the final pressure) and the amount of saturated water using the saturated steam table. The comparison of a steam tank and a steam accumulator, both of which have the same volume, reveals that the steam accumulator can store 10 times as much steam as the steam tank.

Table 6.3.10 Steam Storage in Pressurized Steam Tank

Item		Initial	Final
Pressure	kg/cm² abs	19	3.2
Vessel volume	m³	2	2
Steam unit volume	m³/kg-steam	0.106	0.581
Storage	kg	18.8	3.4
Steam utilized	kg		15.3

Table 6.3.11 Steam Accumulator Simulation

Items		Initial Condition	Final Condition
Pressure	kg/cm² (abs)	19.0	3.2
Saturated water:			
weight	t	1.193	1.014
volume	m³	1.4	1.087
Unit evaporation	t/m³-initial water volume	–	128
Evaporation	kg	–	180

Increasing the steam storage amount by the accumulator is expected to bring about the following energy conservation effects.

- Reduction of steam release amount at the time of steam supply and demand unbalance

- Optimization of air ratio by stabilization of the boiler load.

(7) Consideration of steam pressure reduction

In this plant, back pressure steam from the power generating turbine is used for the process steam. Therefore, if the requied pressure of the process steam is lowered, the output of the power-generating turbine will increase. The present process steam pressure is 2.5 kg/cm² (G), which is supposed to be possibly operated even at about 1.8 kg/cm² (G). Calculation of this effect shows that the turbine's power generating output will increase by approximately 2.2 %.

Since in this plant electric power is supplied independently from the system of the public utility company, no power generation needs to be increased. Hence, the steam volume for the power generating turbine can be decreased by this increase of output. Assuming that unbalance between the demand for the process steam and the demand for steam at the turbine inlet caused by power demand is absorbed by releasing the steam of the low-pressure system, and that there is an allowance for further 2 % more reduction of steam releasing, the reduction of turbine steam will directly lead to the decrease in the evaporation volume at the boiler, that is, the reduction of the fuel used. The fuel saved annually is estimated to be 33,000 m^3, namely, 330 Gcal calculated in terms of calorific value.

Besides, steam has a property that the latent heat of condensation (kcal/kg) increases as the pressure decreases. Therefore, in the heating process, the required steam volume can be reduced by decreasing the pressure of the steam used. In other words, the latent heat is 513.5 kcal/kg for steam pressure of 2.5 kg/cm^2 (G), and 518.7 kcal/kg for steam pressure of 1.8 kg/cm^2 (G). This means that the latter is about 1 % larger, that is, 1 % reduction of steam. Thus in this regard, decreasing the back pressure steam pressure leads to energy conservation.

(8) Power supply and demand

Most of electric power is supplied by private power generation. Here, consideration should be given to a balance between the safety and stable operation at the plant and consideration for energy conservation. The utilization factor (= average power/power generator capacity) of the power generator at our investigation is 48 to 61 %, which means a considerably large allowance in terms of electric power. In this plant, a 3,500 kW power generator is additionally under construction. When this generator starts operation, still more allowance for electric power will be produced. However, the output of the steam turbines, all of which are back-pressure turbines, depends on the steam used in the factory. Therefore, in order to provide flexibility to the operation of power, it will be preferable to install these turbines in parallel with the purchased power system, purchase electricity when the steam volume decreases, and sell it when the steam volume increases.

(9) Centrifugal separator

There are 11 centrifugal separators in total for the massecuite boiled up in the crystallizing pan. For two vertical type 110 kW separators and three 70 kW separators of these 11 separators, pole change is performed at deceleration. Replacing this with an inverter motor or a special motor will allow power regeneration. However, since the time to regenerate electric power is short, modification of the existing facilities alone may be less economical. This should, therefore, be considered at new installation of facilities.

(10) Air compressor

For two 75 kW air compressors intaking the indoor air, it is preferable to intake the outdoor air in order to lower the intake air temperature.

(11) Lighting

At our investigation of the plant, which was out of operation because of maintenance being conducted for the operation for the next time, lights remaining lit up during the day time were noticeable. Roughly estimating from our visual check, approximately 100 fluorescent lights of 40 W seemed to remain lit. Turning off unnecessary lights is the first step to energy conservation. This measure should be positively taken since it is inexpensive, though some branching of the circuits may be necessary.

Assuming that 100 fluorescent lamps of 40 W can be turned off, the following annual reduction of electricity can be attained:

365 days × 10 hours × 100 lights × 0.04 kW = 14,600 kWh/year

(12) Summary of proposals

Table 6.3.12 summarizes the above-mentioned energy conservation measures.

Table 6.3.12 Summary of Proposals

(Japanese Yen base)

Item	Expected Saving: Fuel 10^3 m³/y	Fuel Million yen/y	Fuel %	Electricity MWh/y	Electricity Million yen/y	Electricity %	Total Million yen/y	Investment Million yen	Payback Period year
Adoption of a softening type ion exchange resin	1,108*1	20.3	5.0	-			20.3	100	4.9
Automatic control of the crystallizing pan and adjustment of vacuum degree	2,217*2	40.6	10.0	-			40.6	20*8	0.5
Heat insulation of the steam pipe	(107)*3	(2.0)	(0.5)*5	-			(2.0)	(23)*9	(11.5)*10
Reduction of steam pressure	255*4	4.7	1.2*6	-			4.7	0	0
Turning off unnecessary lights	-			14.6	0.1	0.1*7	0.1	0	0
Total	3,580	65.6	16.2	14.6	0.1	0.1	65.7	120	1.8

(Iran Rial base)

Item	Expected Saving: Fuel N.gas 10^3 m³/y	Fuel Million Rial/y	Fuel %	Electricity MWh/y	Electricity Million Rial/y	Electricity %	Total Million Rial/y	Investment Million Rial	Payback Period year
Adoption of a softening type ion exchange resin	(1,108)*1	(136)	(5.0)	-			(136)	(1,750)	(12.9)
Automatic control of the crystallizing pan and adjustment of vacuum degree	2,217*2	273	10.0	-			273	350*8	1.3
Heat insulation of the steam pipe	(107)*3	(13)	(0.5)*5	-			(13)	(403)*9	(31.0)*10
Reduction of steam pressure	255*4	31	1.2*6	-			31	0	0
Turning off unnecessary lights	-			14.6	1	0.1*7	1	0	0
Total	2,472	304	11.2	14.6	1	0.1	305	350	1.1

*1 19,447,565 m³/y + 2,927,557 L/y × 9,100 kcal/L / 9,1800 kcal/m³ = 22,166 × 10³ m³/y
   22,166 × 10³ m³/y × 0.05 = 1,108 × 10³ m³/y
*2 22,166 × 10³ m³/y × 0.1 = 2,217 × 10³ m³/y
*3 1,046 × 10⁶ / 9,800 = 107 × 10³ m³/y
*4 33 × 10³ m³/y + 22,166 × 10³ m³/y × 0.01 = 255 × 10³ m³/y
*5 107 × 10³ / (22,166 × 10³) × 100 = 0.5 %
*6 255 × 10³ / (22,166 × 10³) × 100 = 1.2 %
*7 14.6 / (12,723 + 10,785) × 100 = 0.1 %
*8 For the agitator only
*9 1,046 × 10⁶ / (24 × 110) / 0.9 × 0.8 = 353 × 10³ kcal/y
   353 × 10³ kcal/y × 64.8 yen/kcal = 23 × 10⁶ yen
*10 A long period is required because of insufficient annual operating days

Energy price in Japan:
   Fuel price: 17,000 yen × 9.8 / 9,100 = 18.31 yen/m³
   Electricity price: 10 yen/kWh
Energy price on Iran Rial base:
   Natural gas: 123 Rial/m³
   Electricity: 100 Rial/kWh
Exchange rate: 1,750 Rial = 1 US Dollar = 100 Japanese Yen
Investment cost is based on that in Japan.

7. APPENDIX

APPENDIX 1

Members of the Factory Energy Diagnosis Team

JICA Team

A. Preliminary Diagnosis (at the first study)

No.	Name	Duty
1.	Mitsuo Iguchi	Leader
2.	Norio Fukushima	(Leader), Analysis of Energy Conservation Potential
3.	Jiro Konishi	Heat Management Technology
4.	Kazuo Usui	Electricity Management Technology

B. Plenary Diagnosis (at the third study)

1. Maintenance of Equipment, and Diagnostic Technology Transfer

No.	Name	Duty
1.	Mitsuo Iguchi	Leader
2.	Norio Fukushima	Energy Conservation Potential Analysis
3.	Seiichiro Maruyama	Process Management Technology
4.	Teruo Anzai	Process Management Technology
5.	Yukio Nozaki	Heat Management Technology
6.	Kenichi Nakayama	Electricity Management Technology
7.	Akihiro Koyamada	Measuring Equipment Technology

2. Steel Industry

No.	Name	Duty
1.	Norio Fukushima	Leader, Analysis of Energy Conservation Potential
2.	Seiichiro Maruyama	Steel Process Management Technology
3.	Jiro Konishi	Heat Management Technology
4.	Kenji Kazuma	Heat Management Technology
5.	Kazuo Usui	Electricity Management Technology

3. Chemical Industry

No.	Name	Duty
1.	Norio Fukushima	Leader, Analysis of Energy Conservation Potential
2.	Kenji Kazuma	Chemical Process Management Technology
3.	Jiro Konishi	Heat Management Technology
4.	Seiichiro Maruyama	Heat Management Technology
5.	Kazuo Usui	Electricity Management Technology

4. Cement Industry

No.	Name	Duty
1.	Norio Fukushima	Leader, Analysis of Energy Conservation Potential
2.	Hisashi Ikeda	Cement Process Management Technology
3.	Katsuhiko Kaburagi	Heat Management Technology
4.	Masami Kato	Heat Management Technology
5.	Toshio Sugimoto	Electricity Management Technology

5. Glass Industry

No.	Name	Duty
1.	Norio Fukushima	Leader, Analysis of Energy Conservation Potential
2.	Masami Kato	Glass Process Management Technology Heat Management Technology
3.	Toshio Sugimoto	Electricity Management Technology

6. Textile Industry

No.	Name	Duty
1.	Norio Fukushima	Leader, Analysis of Energy Conservation Potential
2.	Takashige Taniguchi	Textile Process Management Technology
3.	Jiro Konishi	Heat Management Technology
4.	Shiro Honda	Heat Management Technology
5.	Kazuo Usui	Electricity Management Technology

7. Food Industry

No.	Name	Duty
1.	Mitsuo Iguchi	Leader
2.	Norio Fukushima	(Leader), Analysis of Energy Conservation Potential
3.	Shiro Honda	Food Process Management Technology
4.	Jiro Konishi	Heat Management Technology
5.	Takashige Taniguchi	Heat Management Technology
6.	Kazuo Usui	Electricity Management Technology

PBO Team

A. Preliminary Study

Comprehensive Energy Studies (CES), Sharif University of Technology (SUT)

Mr. Mazhari	Energy conservation
Mr. Akhavan	Energy conservation
Mr. Mianji	Micro level energy management
Mr. Azizi	Macro level energy management
Mr. Shayesteh	Instrumentation
Mr. Moosavi	Macro level energy management
Mr. Mohamadzadeh	Macro level energy management
Mr. Tohangchi	Micro level energy management
Mr. Maboodi	Electrical energy management
Ms. Zarvani	Macro level energy management

Ministry of Industry
Mr. Parsi
Mr. Mohamadzadeh

Advisory Committee
Mr. Alavizadeh

B. Plenary Study

Comprehensive Energy Studies (CES), Sharif University of Technology (SUT)

Mr. Mazhari	Energy conservation
Mr. Akhavan	Energy conservation
Mr. Mianji	Micro level energy management
Mr. Azizi	Macro level energy management
Mr. Sajadifar	Factory management
Mr. Shayesteh	Instrumentation
Mr. Moosavi	Electrical energy management
Mr. Tohangchi	Micro level energy management
Mr. Seid-Reyhani	Micro level energy management
Ms. Zarvani	Macro level energy management

APPENDIX 2

Timetable of the Factory Energy Diagnosis

A. Preliminary Diagnosis (at the first study)

No.	Date	Day of the week	Itinerary
1	Sep. 14, 1995	Thurs.	Departure from Tokyo
2	Sep. 15	Fri.	Arrival at Tehran
3	Sep. 16	Sat.	Meeting with EDMG group Discussion of Inception Report
4	Sep. 17	Sun.	Discussion of Inception Report Meeting with Embassy of Japan
5	Sep. 18	Mon.	Meeting with Advisory Committee Discussion of Inception Report
6	Sep. 19	Tue.	Meeting with EDMG group Meeting with President of SUT
7	Sep. 20	Wed.	Discussion of Inception Report
8	Sep. 21	Thurs.	Preparation for study
9	Sep. 22	Fri.	ditto
10	Sep. 23	Sat.	Survey of Behshahr Industry
11	Sep. 24	Sun.	Survey of Tehran Cement
12	Sep. 25	Mon.	Sign of Meeting Minutes, Tehran → Tabriz
13	Sep. 26	Tue.	Survey of Soufian Cement, Tabriz → Tehran (Konishi)
14	Sep. 27	Wed.	Preparation of report, Tabriz → Tehran (Fukushima)
15	Sep. 28	Thurs.	Preparation for study
16	Sep. 29	Fri.	ditto, Tehran → Esfahan
17	Sep. 30	Sat.	Survey of Sepahan Cement
18	Oct. 1	Sun.	Survey of Polyacryl Iran
19	Oct. 2	Mon.	Survey of Esfahan Steel
20	Oct. 3	Tue.	ditto, Esfahan → Tehran (Konishi)
21	Oct. 4	Wed.	Esfahan → Tehran (Fukushima, Usui)
22	Oct. 5	Thurs.	Visit to 21st Tehran International Trade Fair
23	Oct. 6	Fri.	Preparation for study
24	Oct. 7	Sat.	Survey of Tehran Refinery
25	Oct. 8	Sun.	ditto
26	Oct. 9	Mon.	Survey of Ghazvin Glass Tehran → Bandar Imam
27	Oct. 10	Tue.	Survey of Razi Petrochemical
28	Oct. 11	Wed.	ditto
29	Oct. 12	Thurs.	Bandar Imam → Tehran
30	Oct. 13	Fri.	Preparation for study

No.	Date	Day of the week	Itinerary
31	Oct. 14, 1995	Sat.	Survey of Kashan Velvet & Rayon
32	Oct. 15	Sun.	Preparation of report
33	Oct. 16	Mon.	ditto, Tehran → Ahwaz
34	Oct. 17	Tue.	Survey of Karun Cane
35	Oct. 18	Wed.	ditto
36	Oct. 19	Thurs.	Ahwaz → Tehran
37	Oct. 20	Fri.	Tehran → Mashad
38	Oct. 21	Sat.	Survey of Abkouh Sugar
39	Oct. 22	Sun.	Mashad → Tehran, Preparation of report
40	Oct. 23	Mon.	Preparation of report
41	Oct. 24	Tue.	Preparation of report, Meeting with Dr. Saboohi
42	Oct. 25	Wed.	Review of report
43	Oct. 26	Thurs.	Report to Embassy of Japan
44	Oct. 27	Fri.	
45	Oct. 28	Sat.	Meeting with EDMG member Submission of First Study Team Report
46	Oct. 29	Sun.	Departure from Tehran
47	Oct. 30	Mon.	
48	Oct. 31	Tue.	Arrival at Tokyo

B. Plenary Diagnosis (at the third study)

No.	Date	Day of the week	Itinerary
1	May 26, 1996	Sun.	Departure from Tokyo
2	May 27	Mon.	
3	May 28	Tue.	Arrival at Tehran
4	May 29	Wed.	Meeting with SUT Checking of measuring equipment
5	May 30	Thurs.	Meeting with Embassy of Japan
6	May 31	Fri.	Preparation for survey
7	June 1	Sat.	Technology transfer about measuring equipment Meeting with SUT
8	June 2	Sun.	ditto
9	June 3	Mon.	National Holiday, Preparation for study
10	June 4	Tue.	National Holiday, Preparation for study
11	June 5	Wed.	Meeting with SUT
12	June 6	Thurs.	Preparation for study
13	June 7	Fri.	ditto
14	June 8	Sat.	Meeting with staff in factories
15	June 9	Sun.	ditto, Meeting on the steel industry survey
16	June 10	Mon.	Technology transfer about measuring equipment Meeting on the chemical industry survey
17	June 11	Tue.	Technology transfer about measuring equipment Lecture on energy conservation in steel industry
18	June 12	Wed.	Lecture on energy conservation in chemical industry Preparation for measuring equipment
19	June 13	Thurs.	Report to Embassy of Japan.
20	June 14	Fri.	Preparation for study
21	June 15	Sat.	Survey of Tehran Refinery
22	June 16	Sun.	ditto
23	June 17	Mon.	ditto
24	June 18	Tue.	ditto
25	June 19	Wed.	ditto
26	June 20	Thurs.	Preparation for study
27	June 21	Fri.	Tehran → Esfahan
28	June 22	Sat.	Survey of Esfahan Steel
29	June 23	Sun.	ditto
30	June 24	Mon.	ditto
31	June 25	Tue.	ditto
32	June 26	Wed.	ditto
33	June 27	Thurs.	Esfahan → Tehran
34	June 28	Fri.	Preparation for study

No.	Date	Day of the week	Itinerary
35	June 29, 1996	Sat.	Analysis of collecting data
36	June 30	Sun.	ditto
37	July 1	Mon.	ditto
			Meeting on the cement & glass industry survey
38	July 2	Tue.	Lecture on energy conservation in glass industry
39	July 3	Wed.	Lecture on energy conservation in cement industry
40	July 4	Thurs.	Meeting with Embassy of Japan
41	July 5	Fri.	Tehran → Esfahan
42	July 6	Sat.	Survey of Sepahan Cement
43	July 7	Sun.	National Holiday, Preparation for study
44	July 8	Mon.	Survey of Sepahan Cement
45	July 9	Tue.	ditto
46	July 10	Wed.	ditto
47	July 11	Thurs.	Preparation for study
48	July 12	Fri.	ditto
49	July 13	Sat.	Esfahan → Tehran
50	July 14	Sun.	Survey of Tehran Cement & Ghazvin Glass
51	July 15	Mon.	National Holiday
52	July 16	Tue.	Survey of Tehran Cement & Ghazvin Glass
53	July 17	Wed.	ditto
54	July 18	Thurs.	Tehran → Tabriz
55	July 19	Fri.	Preparation for study
56	July 20	Sat.	Survey of Soufian Cement
57	July 21	Sun.	ditto
58	July 22	Mon.	ditto
59	July 23	Tue.	ditto
60	July 24	Wed.	ditto
61	July 25	Thurs.	Tabriz → Tehran
62	July 26	Fri.	Preparation for study
63	July 27	Sat.	Analysis of collecting data
64	July 28	Sun.	Analysis of collecting data
65	July 29	Mon.	Analysis of collecting data
66	July 30	Tue.	Meeting on the textile & food industry survey,
			Lecture on energy conservation in food industry
67	July 31	Wed.	Lecture on energy conservation in textile industry
68	Aug. 1	Thurs.	Meeting with Embassy of Japan
69	Aug. 2	Fri.	Tehran → Esfahan

No.	Date	Day of the week	Itinerary
70	Aug. 3, 1996	Sat.	Survey of Polyacryl Iran
71	Aug. 4	Sun.	ditto
72	Aug. 5	Mon.	ditto
73	Aug. 6	Tue.	ditto
74	Aug. 7	Wed.	ditto
75	Aug. 8	Thurs.	Esfahan → Tehran
76	Aug. 9	Fri.	Preparatory for study
77	Aug. 10	Sat.	Survey of Behshahr Industry
78	Aug. 11	Sun.	ditto
79	Aug. 12	Mon.	ditto
80	Aug. 13	Tue.	ditto
81	Aug. 14	Wed.	ditto
82	Aug. 15	Thurs.	Preparatory for study
83	Aug. 16	Fri.	Tehran → Ahwaz
84	Aug. 17	Sat.	Survey of Kashan Velvet & Rayon; and Karun Cane
85	Aug. 18	Sun.	ditto
86	Aug. 19	Mon.	ditto
87	Aug. 20	Tue.	Ahwaz → Tehran
88	Aug. 21	Wed.	Preparatory for study
89	Aug. 22	Thurs.	Meeting with Embassy of Japan
90	Aug. 23	Fri.	Tehran → Mashad
91	Aug. 24	Sat.	Survey of Abkouh Sugar
92	Aug. 25	Sun.	ditto
93	Aug. 26	Mon.	ditto
94	Aug. 27	Tue.	Mashad → Tehran
95	Aug. 28	Wed.	Discussing and signing the Minutes of Meeting Report to Embassy of Japan
96	Aug. 29	Thurs.	Departure from Tehran
97	Aug. 30	Fri.	
98	Aug. 31	Sat.	Arrival at Tokyo

APPENDIX 3

Equipment List

No.	Name	Set (s)
1.	Energy Audit Bus	1
2.	Ultrasonic liquid flow meter	3
3.	High temperature anemometer for gas	6
4.	Pitot type flow meter	4
5.	Voltex type flow meter	3 × 3
6.	Oxygen meter for exhaust gas	4
7.	Carbon dioxide and monoxide meter for exhaust gas	4
8.	Pretreatment unit for sampling exhaust gas	4
9.	Sampling tube for exhaust gas	1
10.	Thermometer for surface	2
11.	Thermocouple with compensate cable for gas	50
12.	Suction pyrometer	2
13.	Radiation thermometer (low range)	2
14.	Radiation thermometer (high range)	2
15.	Glass thermometer	5
16.	Hygrometer	10
17.	Thermal video system	1
18.	Portable hybrid recorder	6
19.	Desk-top type personal computer	1
20.	Note type personal computer	2
21.	SC meter	2
22.	pH meter	2
23.	Digital low pressure indicator	2
24.	Pressure transmitter for steam	3 × 3
25.	Clamp-on power meter	5
26.	Clip-on AC power meter	3
27.	Tacho meter	2
28.	Lux meter	2
29.	Tester	2
30.	Low voltage detector	5
31.	Heat-proof gloves	5
32.	Cobalt glass	10
33.	Camera	1
34.	Insulation rubber gloves	5
35.	Cord reel and others	1
36.	Stopwatch	2
37.	Carrying cart	4
38.	Long table	3
39.	Transducer for electricity (5 kinds)	2 × 5
40.	Training unit for combustion	1
41.	Training unit for liquid flow	1
42.	Training unit for gas flow	1

OVERVIEW OF MAIN EQUIPMENT

1. Ultrasonic liquid flow meter (Fuji Electric Co., Ltd.: FLB)

   This meter is used to measure the flow rate of liquid such as feed water to the boiler or fuel. Since ultrasonic wave is used for measurement, measurement from outside the piping is possible. The meter has a feature that there is no pressure loss since the liquid is not directly contacted.

2. High temperature anemometer for gas (Kanox Japan Inc.: 6161)

   This is a heat ray air flow meter used to measure the flow speed of the exhaust gas from the boiler, combustion furnace, or the like. Air flow of a high temperature up to 500 °C can be measured.

   Data is output as analog signals and can be stored on a recorder.

3. Vortex type flow meter (Yokogawa Electric Corporation: YF100)

   This flow meter is incorporated into the piping line to measure the flow rate. By detecting the Karman vortex stream, the flow rate is measured.

   Any object such as liquid, gas, or steam can be measured.
   Data is output as analog signals and can be stored on a recorder.

4. Oxygen meter for exhaust gas (NGK Insulators, Ltd.: PA210)

   This densitometer is used to measure the oxygen content in the exhaust gas from the boiler or combustion furnace. The measurement range covers 0 to 25 % of O_2.

   As the measurement theory, the zirconia system using the electro-chemical oxidization and reduction reaction is adopted.

   Data is output as analog signals and can be stored on a recorder.

5. Corbon dioxide and monoxide meter for exhaust gas (Shimadzu Corporation: CGT-10-1A)

   This meter is used to measure the CO/CO_2 content in the exhaust gas from the boiler or combustion furnace. The measurement range is 0 to 0.1 vol% for CO and 0 to 15 vol% for CO_2.

   As the measurement theory, the non-dispersing type infrared absorption system using the infrared ray absorption rate is adopted.

   Data is output as analog signals and can be stored on a recorder.

6. Pretreatment unit for sampling exhaust gas (Shimadzu Corporation: CFP-301)

This is a supplementary equipment for a gas analyzer that removes dust and vapor from the exhaust gas and cools down the exhaust gas to analyze the exhaust gas with the O_2 meter or CO/CO_2 meter.

The major components include the drain separator, gas suction pump, filter, electronic cooler, and flow meter.

7. Thermometer for surface (Yokogawa Electric Corporation: 2542)

This is a handy thermometer using a thermocouple and used to measure the furnace surface temperature.

Since the sensor is directly contacted to an object to be measured, a precise temperature can be easily measured.

The measurement range is –50 to 600 °C.

8. Suction pyrometer (Kawaso Electric Industrial Co., Ltd.: SU6-B-13-2.0)

This pyrometer is used to measure the temperature of the hot gas from the boiler or combustion furnace. A platinum-rhodium thermocouple is used for the sensor and the radiation shield minimizes the effects of radiation from the hot furnace wall.

Through high-speed suction of the exhaust gas onto the thermocouple at the same time, effects of heat conduction can be eliminated to measure the gas temperature.

Data is output as analog signals and can be stored on a recorder.

9. Radiation thermometer (Hayashi Denko: RT70-1, -2)

This is a contactless thermometer using infrared ray and allows measurement from a remote location. The maximum value, minimum value, temperature gradient, and average temperature can be calculated during measurement and up to 100 sets of these values can be stored.

For the low-temperature use, the measurement range is –30 to 1,200 °C. For the high-temperature use, it is 600 to 3,000 °C.

10. Thermal video system (Nippon Avionics Co., Ltd.: TVS-2000Mk II)

This equipment is used to measure the temperature of an object to be measured in non-contact mode and can display thermal imagery on the built-in color monitor.

Data can be stored on a floppy disk. By using dedicated PC software, analysis, VTR recording, and photo recording are possible.

11. Portable hybrid recorder (Yokogawa Electric Corporation: 3750)

Up to 20 analog signals output from each measuring component can be read. They can be recorded on the built-in IC memory card and printed with the built-in printer.

Data recorded on the IC memory card can be transferred from the dedicated memory card reader to a PC, allowing analysis with dedicated.

12. SC meter (Yokogawa Electric Corporation: SC82)

This is a portable conductivity meter used to measure the quality of water supplied to or drained from the boiler. The measurement range is 0 to 200 mS/cm.

The temperature of liquid to be measured is 0 to 80 °C. Temperature can also be measured along with conductivity measurement.

13. pH meter (Yokogawa Electric Corporation: PH81)

This is a portable ph meter used to measure the quality of water supplied to or drained from the boiler. The measurement range is pH0 to pH14.

The temperature of the liquid to be measured is 0 to 80 °C.
Liquid temperature can also be measured along with pH measurement.

14. Digital low pressure indicator (Seiritsu Engineering Co., Ltd.: DLM-10-1512)

This is a portable fine differential pressure gauge used to measure the gas pressure. The pressure range is –50 to 50 mmH_2O for the positive/negative pressure.

This gauge is mainly used to measure the pressure in the heating furnace or the like.

Data is output as analog signals and can be stored on a recorder.

15. Pressure transmitter for steam (Nagano Keiki Seisakusho: KH15)

This is a pressure transmitter using a semiconductor distortion gauge for the detector and converts a pressure into electrical signals and transmits them.

Data is output as analog signals and can be stored on a recorder.

16. Clamp-on power meter (Hioki E.E. Corporation: 3165)

This is a clamp type watt-meter that allows measurement for single phase to three-phase 4-wire type. Based on the measured voltage, current, and effective power, calculation of the wattless power, apparent power, and power factor can be indicated on the built-in printer.

Data is output as analog signals and can be stored on a recorder.

17. Clip-on AC power meter (Yokogawa Electric Corporation: 2433-11)

This is a portable watt-meter that allows measurement of kW, Vrms, and Arms of a single-phase or balanced three-phase circuit with a clamp sensor.

The circuit voltage is up to 600 V (AC).
Data is output as analog signals and can be stored on a recorder.

18. Training unit for combustion (Tokyo Denki Sangyo Co., Ltd.)

This is a small electrical furnace that allows on-the-job training on heat management using the surface thermometer, thermocouple, and radiation thermometer.

For the power supply part, on-the-job training on electricity management using a watt-meter can be performed.

19. Training unit for liquid flow (Tokyo Denki Sangyo Co., Ltd.)

This equipment contains piping that circulates water with a pump. The oval flow meter and vortex flow meter are incorporated into this equipment.

On-the-job training on the flow rate with the oval flow meter, vortex flow meter, and ultrasonic flow meter is possible.

For the power supply part, on-the-job training on electricity management using a watt-meter can be performed.

20. Training unit for gas flow (Tokyo Denki Sangyo Co., Ltd.)

This is an equipment used to measure the gas flow rate and pressure by feeding air with a fan for on-the-job training.

This equipment allows on-the-job training on measurement of the gas flow rate with the anemomaster and Pitot tube and on pressure measurement with the digital fine differential pressure gauge.

For the power supply part, on-the-job training on electricity management using a watt-meter can be performed.

JICA