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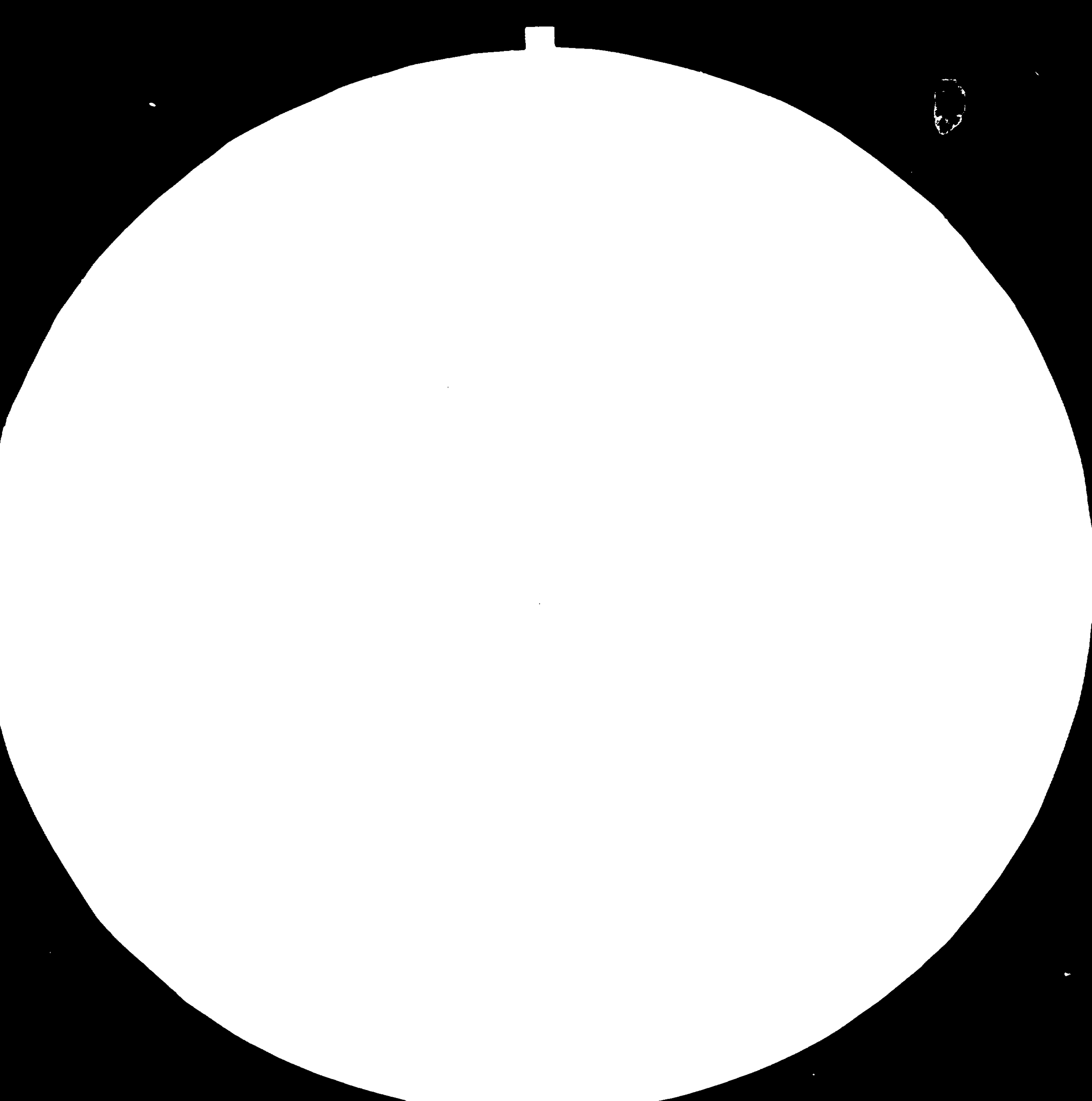

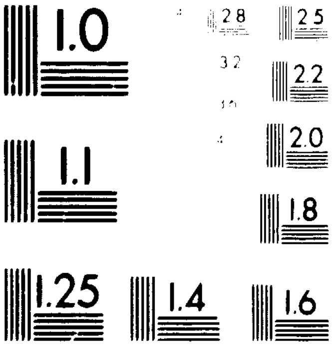

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REPORT ON ASSESSMENT OF ENERGY CONSERVATION MEASURES AT PLANT LEVEL IN MALAYSIA*

Prepared by

UNIDO Secretariat**

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** Based on the work of:
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CONTENTS

I. GENERAL REPORT

1. Purpose of the Survey

This survey report was compiled on the results of energy diagnoses of nine factories in Malaysia which were conducted by three Japanese experts and their four Malaysian counterparts as a part of the ASEAN Energy-Conservation Project of United Nations Industrial Development Organization (UNIDO).

The purposes of the energy diagnoses of factories were:

1) To transfer the experience technology, and know-how of energy-conservation and its practical application;
2) To assess and provide practical advice on energy-conservation measures;
3) To provide on-the-job training for energy-conservation advisors who will be put in charge of future advisory activities on a national program level.

2. Survey Team Members

The members of survey team are as shown in Table 2.1.

The survey team consisted of one diagnoser in charge of energy management, thermal energy management, and electric energy management, respectively.

Their counterparts from the Ministry of Energy, Telecommunications and Posts and the National Electricity Board who are listed in Table 2.2 went along with the survey team to extend their cooperation and to learn diagnostic techniques and know-how.

In addition, Dr. Radu, who is attached to the National Electricity Board, took part in the diagnoses as an observer.

Table 2.1 Member List of the Survey Team

	Name	Present Post
Team Leader and Energy Management Expert	Masataka Eguchi	Manager, Technical Division The Energy Conservaticn Center (E.C.C.) Registered Diagnoser of the E.C.C. Energy Management Expert (Team Leader)
Thermal Energy Management Expert	Ryoji Takahashi	Director, Technical Division Energy Engineering Co., Registered Consultant Engineer Manager of Pollution Control Activities
Electrical Energy Management Expert	Toshio Sugimoto	Registered Diagnoser of the E.C.C. Registered Consultant Engineer Chief Electrical Engineer

Table 2.2 Malaysian Counterparts

Name	Attached to
Dr. Mohd Ariff Araff	Chief of Counterparts National Electricity Board
Dr. Ong Peng Su	National Electricity Board
Mr. Ahmad Feisal	National Electricity Board
Mr. Alizan Ab. Manan	Ministry of Energy, Telecommunications & Posts

3. Schedule for the Survey

March 14	(Mon.)	Travel from Tokyo to Kuala Lumpur
15	(Tue.)	Prearrangement for meeting
16	(Wed.)	Preparatory meeting at the Ministry of Energy, Telecommunications and Posts
17	(Thu.)	A.M. Testing and adjustment of instruments which had been brought from Japan P.M. Instruction on heat management for counterparts
18	(Fri.)	A.M. General meeting at the Ministry of Energy, Telecommunications and Posts
19	(Sat.)	Explanation of the use of instruments for counterparts
21 (Mon.) ~ April 19 (Tue.)		Diagnosis of selected factories
20	(Wed.)	A.M. at National Electricity Board 1. Cleaning, maintenance, and testing of a number of instruments which had been brought from Japan by experts for delivery to the Malaysian Government 2. Instruction on the maintenance of instruments P.M. at the Ministry of Energy, Telecommunications and Posts

April 20	(Wed.)	Presentation of the instruments which had been brought from Japan by experts to Mr. Syed, representative of the Ministry of Energy, Telecommunications and Posts in the presence of Mr. Luttik, UNDP.
21	(Thu.)	Final discussion with Japanese experts and Malaysian counterparts 1. Checking whether there were missing data 2. Offering advice to counterparts
22	(Fri.)	Notice to relevant office of the termination of the first phase of this project, and departure from Kuala Lumpur
23	(Sat.)	Arrive at Tokyo/Narita

4. Factories Diagnosed

The factories diagnosed are as shown in Table 4.1. All of these factories are located in Kuala Lumpur and its periphery.

Table 4.1 Factories Diagnosed

Name of Factory	Products	Date of Diagnosis
MARCO SHOE SDN. BHD.	Shoes, rubber mats etc.	21∿22 Mar.
USMETA SDN. BHD.	Retreated tyres	18∿19 Apr.
GOH BAN HUAT POTTERY WORKS SDN. BHD.	Sewer pipe, sanitary wares	25∿26 Mar.
SOUTH EAST ASIA FIREBRICKS INDUSTRIES SDN. BHD.	Refractories, fire-bricks, heat insulating bricks	28∿29 Mar.
GENERAL CERAMIC MANUFACTURES SDN. BHD.	Ceramic wall tiles	31 Mar.∿1 Apr.
MALAYA INDUSTRIAL & MINING CO., BHD.	Portland cement	14∿15 Apr.
CHEMPAKA NEGRI LAKSHMI TEXTILES SDN. BHD.	Textile yarn	4∿5 Apr.
FUSAN FISHING NET MANUFACTURING BHD.	Fishing nets, ropes, agricultural nets	7∿8 Apr.
KIMA SDN. BHD.	Cotton textiles	11∿12 Apr.

5. Survey Procedure

5.1 Factory Diagnosis

5.1.1 Preliminary study through questionnaire

A questionnaire (ANNEX I) was sent out in advance via the Ministry of Energy, Telecommunications and Posts to the selected factories asking them to give the following information:

(1) General information on the factory -
name and address of factory, names of officers, type of industry, capital, annual sales, number of workers, number of technicians, major product, and production capacity;

(2) Energy consumption -
fuel, electricity, and water;

(3) Major energy consuming facilities -
name, type, year installed, fuel used and operating hours;

(4) Production process chart;

(5) Energy flow chart;

(6) One-line diagram

(7) Plant layout; and

(8) Problems to be solved in advancing energy conservation

5.1.2 Interviews with plant managers

In the light of the questionnaires returned and the energy management checklist (ANNEX II) , an interview was held with plant managers to look into:

(1) current production and sales conditions,

(2) energy conservation measures taken so far,

(3) energy management situation, and

(4) problems to be solved in terms of production.

5.1.3 Overall factory inspection

An overall inspection was made of each factory, following its manufacturing processes, in order to gain an understanding of:

(1) general management conditions,

(2) layout, and

(3) priority facilities to be surveyed and measured.

5.1.4 Survey and measurement

Priority facilities were surveyed according to the items stated in the checklist (ANNEX II) by :

(1) measuring the dimensions of facilities;

(2) collecting data from the factory's records, and from meters and gauges; and

(3) carrying out measurement using measuring instruments brought in (ANNEX III) .

The conditions examined were:

A. fuel combustion,

B. heating, cooling, and heat transfer,

C. prevention of heat release,

D. waste heat recovery,

E. conversion of heat into motive power,

F. electricity loss by resistance, etc., and

G. conversion of electricity into motive power and heat.

5.1.5 Discussions

The survey and measurement results were outlined to factory managers and problem points were discussed.

5.2 Transfer of Techniques to Malaysian Counterparts

5.2.1 Handling of measuring instruments

Before making a factory diagnosis, the Malaysian counterparts were instructed at the National Electricity Board (NEB) in the function of measuring instruments, their uses, and how to handle them according to the manuals.

Later, they were given practical guidance in measurement when a factory was diagnosed.

5.2.2 Guidance in diagnostic technology

At the NEB, the Malaysian counterparts were provided with necessary information on the items stated in the checklist and their meanings.

Also, while data was analysed after the diagnoses, the Malaysia counterparts were given guidance in diagnostic technology. They were taught what points should be considered in a diagnosis, how data should be checked and put in order, what information could be obtained from the data, and how data should be calculated for analysis.

6. Results of Factory Diagnosis

6.1 Factory Management

6.1.1 Level of consciousness of energy conservation of the plant operators and managers

Generally speaking, all the plant operators and managers, it seemed, were well aware of the necessity for energy conservation in view of soaring energy prices. There were very few cases, however, where some specific energy-saving measures were taken. Only one factory had set a target for energy-conservation, and no factories had made recent energy-saving investments.

6.1.2 Management system for promoting energy-conservation

There were a few cases where the management system wor ed with energy conservation.

One factory had an energy-conservation committee, and three factories had cost savings committees or quality and production committees. No other factories had such committees.

6.1.3 Understanding and measurement of energy consumption

To accurately grasp the quantitative aspect of energy consumption is the starting point as well as the most basic thing for energy conservation. The following were the situations observed in the nine factories which we visited.

(1) Instruments for measuring and control were not provided in many of the factories. There were some but were out of order. There was no factory which was equipped with a boiler with a water meter. There

were only two factories in which fuel flow meters were provided. It is impossible under these situations to constantly check the boiler efficiency. There were a number of factories where thermometers, ammeters, volt meters, and power factor meters were either lacking, or left unrepaired, or in use without knowing that they were out of order.

(2) There were many factories where workers knew only vaguely the daily energy consumption, or did not know it at all. As for power consumption, 6 out of 9 factories were dependent on the N.E.B. bill. As for fuel consumption 2 out of 8 factories were dependent on the supplier's bill.

6.1.4 Maintenance of equipment

There were some factories where checking and maintenance of equipment were not properly done. For example, we observed that drive-belts were loose, insulation materials of steam-pipes were fallen off, steam was leaking, and measuring instruments were out of order. These things could cause, directly or indirectly, energy losses, or could cause to shorten the life of equipment.

6.1.5 Safety management

Though this is not directly related to energy-conservation, it is necessary to keep equipment and measuring instruments in a state in which inspection can be made easily. For this reason, it is important to pay attention to the safety measures of equipment and to keep equipment in good order.

For example, we frequently observed the following situations:

(1) The rotors of belt conveyors, and pullies are not covered.

(2) There is no safe footing for measuring instruments, sensors, etc. placed at high position.

(3) Equipment and measuring instruments are not properly aligned, making it difficult to inspect them.

6.1.6 Employee training

Observation of the employee training was as follows:

(1) There was practically no systematic training given to workers. But there were 2 factories where managers were giving instructions to workers. We often heard managers saying that workers had very low consciousness or desire for work. But, we saw no efforts being made for employee training. It is important to improve the level of technical people, but for energy conservation, it is extremely useful to enhance the level of skilled people who are directly involved in energy consumption.

(2) All companies provide seminars to technical people.

(3) There was no factory that employed a suggestion system for work improvement. There was a factory where we saw a suggestion box. But, according to people there was no single suggestion ever made.

(4) Incentive system should be established at factory level for encouragement of factory workers.

6.1.7. Other problems encountered by factories in energy conservation

What and how the factories are thinking about the problems in the course of promotion of energy conservation are represented by the Questionnaire (Attachment 1). The results are shown on Table 6.1. As the results were from only 7 factories, it cannot be concluded that the problems are common to many factories. But it is thought they show the trend. The main items are as follows:

(1) Employees' consciousness is low.

5 of 7 factories pointed out that employees' consciousness is low. As I have discussed in Paragraph 6.1.6., employees' high or low level of consciousness of energy conservation much affects the promotion of energy conservation.

It is a responsibility of factory management to level up the employees' energy conservation consciousness.

(2) System of research and development is not sufficient.

Various reasons can be thought for this. The most important thing will be to foster talent or expert.

(3) Difficulty in obtaining good energy conservation equipment.

The reason for the difficulty is not clear. Whether it is because of cost, or insufficient knowledge of selection, or any other reasons. Therefor, comments are impossible.

However, if one simply thinks that installation of energy conservation equipment is energy conservation, it is wrong.

Generally, the procedure for energy conservation promotion consists of 3 steps:

1st Step: After grasping the state of energy consumption, to strengthen the operation control, and to correct the useless consumption.

2nd Step: To introduce energy conservation equipment for automation, recovery and utilization of energy,etc.

3rd Step: A wide improvement by means of change of production technology, change of process, etc.

In this case, if 2nd Step is entered with insufficient 1st Step, expected effect cannot be obtained in most cases. It must be carefully examined.

(4) The facilities are superannuated.

Generally, the more superannuated the equipments are, the worse is the energy efficiency. Consequently, in a case of such equipments, strengthened management should obtain good results without special costs.

(5) Shortage of measuring equipments.

For Grasping the quantity of energy, measuring equipments should be installed for energy management.

Table 6.1. Replies to Questionnaire "Problems Encountered in The Promotion of Energy Conservation" (reply numbers:7)

Question	Numbers
(1) Prospect of energy price is not clear.	0
(2) The propotion of energy cost in the whole cost of enterprises is small.	0
(3) Increase of energy cost can be covered by raising the prices of products.	2
(4) Instability of enrgy supply. (power stoppage, etc.)	1
(5) Shortage of engineers.	2
(6) Difficulty in obtaining good energy conservation equipments.	3
(7) Information such as active cases is not easy to obtain.	1
(8) System of research and development is not sufficient.	4
(9) Shortage of fund for facility improvement.	1
(10)The facilities are superannuated.	3
(11)Employees' consciousness is low.	5
(12)No personnel is available who can educate the employees.	0
(13)Shortage of measuring equipments.	3
(14)No time to analyze energy consumption rate.	2
(15)Shortage of information on government's measures.	0
(16)Shortage of government's subsidiary measures.	2
(17)Others	1
Total	30

6.2 Situation of Thermal Energy Consumption

6.2.1 Fuel Combustion in Boilers

(1) O_2 Content in Flue Gas

The results of diagnosis of 4 factories which have package boilers are as shown in Table 6.2.1 .
With the exception of one factory, O_2content in flue gas of the other 3 factories have values about 9%. The recommended value for O_2 content in flue gas of package boilers of similar size and loading factor at 70% in Japan is about 5%. This value is equivalent to air ratio in 1.3 .
The O_2 content must be improved by controlling the primary or secondary air for combution without smoking from the stacks. Due to O_2 control of flue gas, the fuel saving of 6% to 14% of the total fuel consumption of the boilors would be achieved with no investment.

(2) Dispersion Heat Loss through Boiler Surfaces

Generally, the surface of package boilers consist of the cylindrical, front and back parts. Although the surface area ratio of the cylindrical part to total is about 60 to 80%, the contribution of the dispersion heat loss is not so much because of relatively low temperature from 50 to 70°C. On Otherwise, the surface temperature of the front and back parts are approximately a range between 100 and 104°C. It is, therefore, more desirable to insulate the front and back parts than the cylindrical part.

Notes 1) ; (value) of m in Flue gas column air ratio.

Table 6.2.1 Summary of Boiler Operations

Factory	No.	Fuel type Composition % C	H	S	Net Cal. Value kcal/kg	Flue Gas Condition [1] O_2 %	Temp. °C	Heat Balance Sheet (per kg fuel) Flue gas H.L kcal	%	Disper. H L kcal	%	Blow-down kcal	%	Steam %
A		85	14	1	9,976	9.5 m = (1.83)	195	1,151	11.3	230	2.2	50	0.5	86.0
B		85	14	1	10.135	9.0 (1.75)	240	1,429	13.1	196	1.8	83	0.8	82.4
H	1	85	13	2	9,576	13.0 (2.63)	257	2,192	22.9	261	2.7	273	2.8	76.4
H	2	85	13	2	9,576	12.2 (2.39)	254	1,879	19.6	153	1.6	233	2.4	71.6
I	1	85	12	3	9,624	10.5 (2.00)	220	1,384	14.4	106	1.1	16	0.1	84.4
I	2	85	12	3	9,624	5.1 (1.31)	198	814	8.5	100	1.0	16	0.1	90.3

In practice, it is very difficut to accurately estimate the heat loss dispersed through the heated surface, because it depends on the a lot of conditions, that is, wind velocity, shape, roughness, material and own temperature of the surfaces. However even though it is rough, it is necessary to estimate the dispersion heat loss for preparing the heat balance sheet.

Here we have two methods to estimate the such heat loss, one is to directly get the heat flux using the heat flux meter, and other is to calculate it using the surface temperature and reasonable heat transfer coefficient assumed by experience. On the case of not possessing the heat flux meter, we must follow in later and get the heat flux by calculation as follows ;

$$\text{Dispersion Heat Loss} = \text{Assumed Heat Trans. Coeff.} \times \text{Area} \times (T - T_o)$$

where generally the heat transfer coefficient of above equation will be ranging between 10 to 20 $^{kcal}/_{m^2 {}^\circ C\ hr}$, and T and T_o are the surface and ambient temperature respectively. The sized area in m^2 should be sured to have approximately uniform ambient condition. According with the heat balance of boilers which are is the basic information for energy management and in any case, must be prepared by the engineer engaging in the energy problems of own factory, it is clear that the approximate amount of heat loss by dispersion from boiler surface would be calculated about 1 to 1.5% of the total fuel consumption. Then it is effective to confirm roughly and quickly the temperature pattern of surface, in order to make a plan for the energy conservation.

(3) Flue Gas Temperature

In Japan, the factories which have the boilers of capacity of not more than 10 tonnes steam/hr and 70% of loading factor are recommended to operate the boilor at flue gas temperature less than 320°C. According with the result of diagnosises in this surveys, above criteria has been cleared on all the factories. But this criteria should be appreciated as maximum and allowable values. Actually it is better to keep it as low as possible. However when the high sulphur fuel is using in boilers, the flue gas temperature should not be decreased the sulphuric acid dew point in order to prevent the corrosion. For example, the minimum allowable temperature of the flue gas is about 170°C for fuel with 1 to 2% S content.

On practice, the flue gas temperature can be reduced by the following measures ;

(a) to remove the scale on inside and outside of boiler tubes at overhaul,

(b) to carry out the routine cleaning of the burner tips in order to ensure the complete combustion, and

(c) to install the air preheater or economizer on the way of flue gas ducts with some modification of the forced draft fans of boiler in order to recover from the flue gas.

(4) Blow-down Heat Loss

It has been observed that all the factories do not check the boiler water quality such as PH and electrical conductivity before each blow-down operation is carried out. The recommended procedure would be to make the operation manual of blow-down, that is, how long of period and how much, on being aware of the boiler water quality.

The amount of the fuel saving achieved by resonable blow-down operation would be about 0.5 to 1.0% of the total fuel consumption of the boilers.

It is to be noted that the recommended values for water quality of small package boilers in Japan are as follows;

PH :	11.0 to 11.8
Electrical Conductivity :	under 6,000µS/cm .

the suitable operation of blow-down would cause not only the fuel saving, but also the saving of the chemical for boiler water.

6.2.2 Fuel Combustion in Industrial Furnaces

The industrial furnaces which have been diagnosed in this study are classified as follows ;

(1) Tunnel Kiln

(2) Shattle Kiln

(3) Rotary Kiln (including Rotary Dryer)

(4) Grate Kiln

(5) Spray Dryer

Generally, the measured values of O_2 content in the flue gas are over 5% which indicate the possibility of the recovery of wasted heat through the stacks of the kilns. The surface temperature on walls and roofs of all furnaces except some parts of rotary kiln are well below the recommended values on maximum allowable temperature.

However, because of the raising cost of fuel, it would be suitable to apply the suitable insulation to lower down the surface temperature as much as possible, depending upon the availability of financial resouces on the factories. Especially in the case of tunnel kilns, the heat of the flue gas should be fully utilized for the preheat of any raw material.

The summary on daily operation in miscellaneous kiln listed up above are shown in table 6.2.2. Generally speaking, almost of all kilns in factory survayed on this diagnosises are operated relatively resonable comparing to similar Japanese industries.

Table 6.2.2 Summary of Miscellaneous Kiln Operation

Factory	Type of Kiln / Type of Operation	Fuel Specification: Type of Fuel	Composition % C	Composition % H	Composition % S	Net C.V. kcal/kg	Heat Balance per hr: Input: Fuel x Mcal	Output: Flue gas Heat loss x Mcal	Output: Dispers. Heat l. x Mcal	Output: Other x Mcal	Output: Prod. & Req. heat x Mcal	Appearance heat Efficiency
C	Shuttle / Batch	Diesel	85	14	1	10,145	48,669 /batch 100%	14,617 /batch 30.0%	6,341 /batch 13.1%	12,952 /batch 26.6%	14,729 /batch 30.3%	30.3%
D	Tunnel / Contin.	Diesel	86	13	1	10,200	584.4 100%	356.1 61.0%	199.8 34.2%	13.1 2.2%	15.4 2.6%	20.7%
E	Tunnel / Contin.	Diesel	85	14	1	9,800	1,110.0 100%	320.0 28.8%	620.6 55.9%	3.0 0.3%	166.9 15.0%	27.5%
E	Spray Dryer / Contin.	Diesel	85	14	1	9,800	1,500.0 100%	319.0 21.3%	135.0 9.1%	231.9 15.4%	813.3 54.2%	53.0%
F	Clinker Rot. Kiln / Contin.	Fuel oil	84	12	4	9,500	8,225.0 90.3%	2,133.0 23.5%	974.0 10.7%	668.0 7.3%	5,329.0 58.5	58.5%
F	Rotary Dryer / Contin.	Fuel oil	84	12	4	9,500	*9,500.0 100%	*1,162.0 12.2%	*3.404.0 35.8%	*930.0 9.5%	*4,00[illegible].0 42.2%	27.1%

Note ; Values of mark * is per kg

6.2.3 Steam Consumption in Factories

The modes of steam consumption by the diagnosed factories are as follows ;

(1) In rubber-product industries, steam is consumed for valcanizing and pressing processes.

(2) In textile industries, steam is consumed for dyeing, stretching and finishing processes.

Most of the piping lines of steam between the boiler and steam consuming facilities are appropriately insulated except in areas which are located near the boilers and facilities. According with the normal "house-keeping" for maintenance, the wasted heat because of broken insulation of steam piping should be easily improved.

At the first, the engineer engaging in energy problems must be familiar on th calculation of steam demand and supply and must find out where is waste-points in own factories.

6.3 Electrical energy consumption

6.3.1 Electric power managements

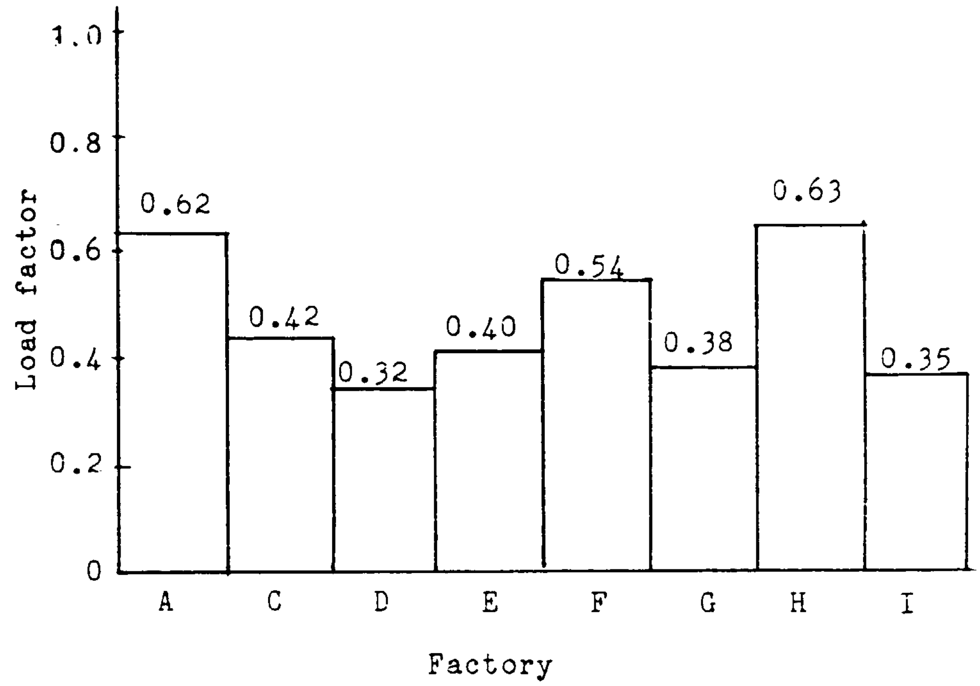
With the exception of the two large textile factories which we have visited where electric energy comsumption log books are properly kept, the remainder of the factories have no standard procedures of recording electric energy consumptions of the factories either daily or weekly. For good energy management it is necessary to analyze daily or weekly energy consumption patterns as in the event of wasteful energy utilization, the practice can be quickly detected and countermeasures can immediately be introduced to avoid further wastage.

6.3.2 Electric source

Except for two factories which received 11 kV (H.V) supplies from the utility (National Electricity Board of the States of Malaya), the others are connected to 415 volts, 3 phase distribution voltage. All factories have equipments rated about 415 volts.

(1) Transformers

The load factors in all factories against the rated transformer capacities are low (around 0.5). These values are unusually low for factories of these sizes. The load factor histogram is as shown in Figure 6.3.1. It was also observed that the transformers were operating at a higher temperature rise (hot) in spite of the low load factor.



Figuar 6.3.1 Load factor histogram of the eight factories

As stated earlier all factories have installed large capacity transformers of sizes either 750 kVA, 1000 kVA or 1250 kVA. These capacities provide large margins of unnecessary iron losses.

(2) Supply voltage

The name plate ratings of various equipments and motors value almost between 400 volts to 420 volts, but the supply voltages of the six factories were kept between 420 volts to 440 volts, remainder factory's supply voltage were lower than the rating voltage of equipments. The supply voltage histogram of the various factor is given in Figure 6.3.2.

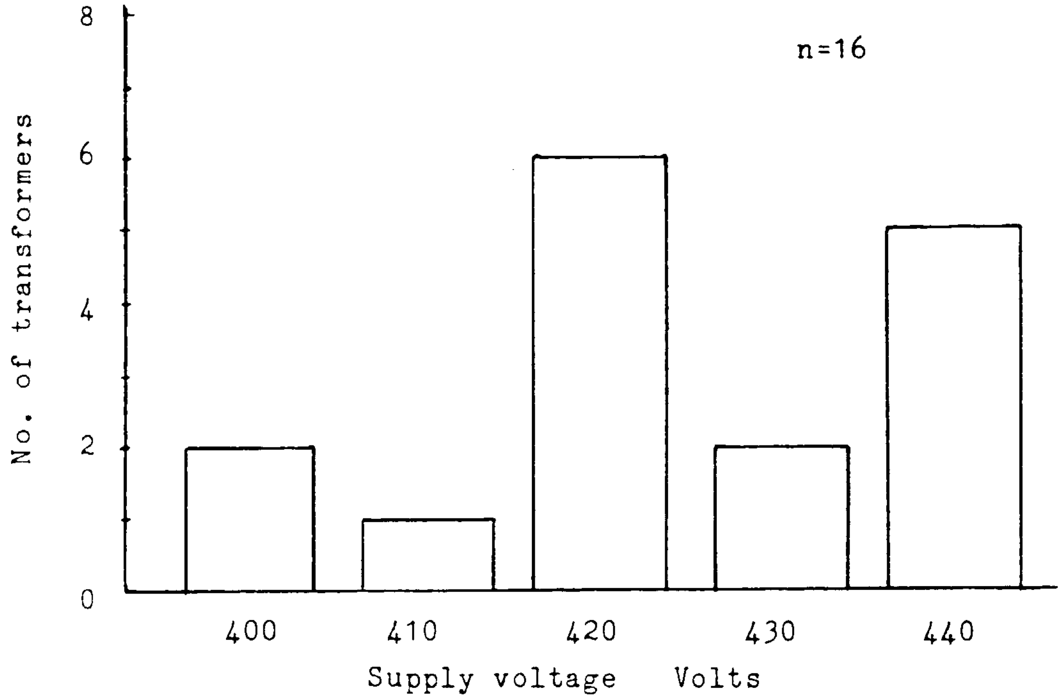


Figure 6.3.2 <u>The secondary supply voltage histogram of transformers in the factories</u>

Only six transformers in two factories were maintained at comparatively good voltage between 420 volts and 430 volts while others were either too low or too high.

(3) <u>Power and static capacitors</u>

All the eight factories (except B factory) have automatic power factor correction equipments. Except for one factory where the power factor correction equipment was found faulty, the others maitained good power factor between 0.85 to 0.95. However most of the power factor correction equipments were installed in poorly ventilated rooms, such as excessive temperature rize and high losses of these equipments were recorded.

It was also found that the actually measured capacities of the power factor correction equipments have decreased and in our opinion this is mainly due to high supply voltage.

(4) <u>Phase current balance</u>

Generally the secondary current of all transformers with the exception of two were found to be balanced.

(5) <u>Understanding of the electrical Tariff</u>

It is vital for all factory managements to understand the Tariff and conditions of electricity, as this would enable them to plan the operations of the factories such that electrical energy cost can be reduced. Further to this it can also enable factory managements to forecast and provide realistic targets for energy conservation.

6.3.3 <u>Electrical loads</u>

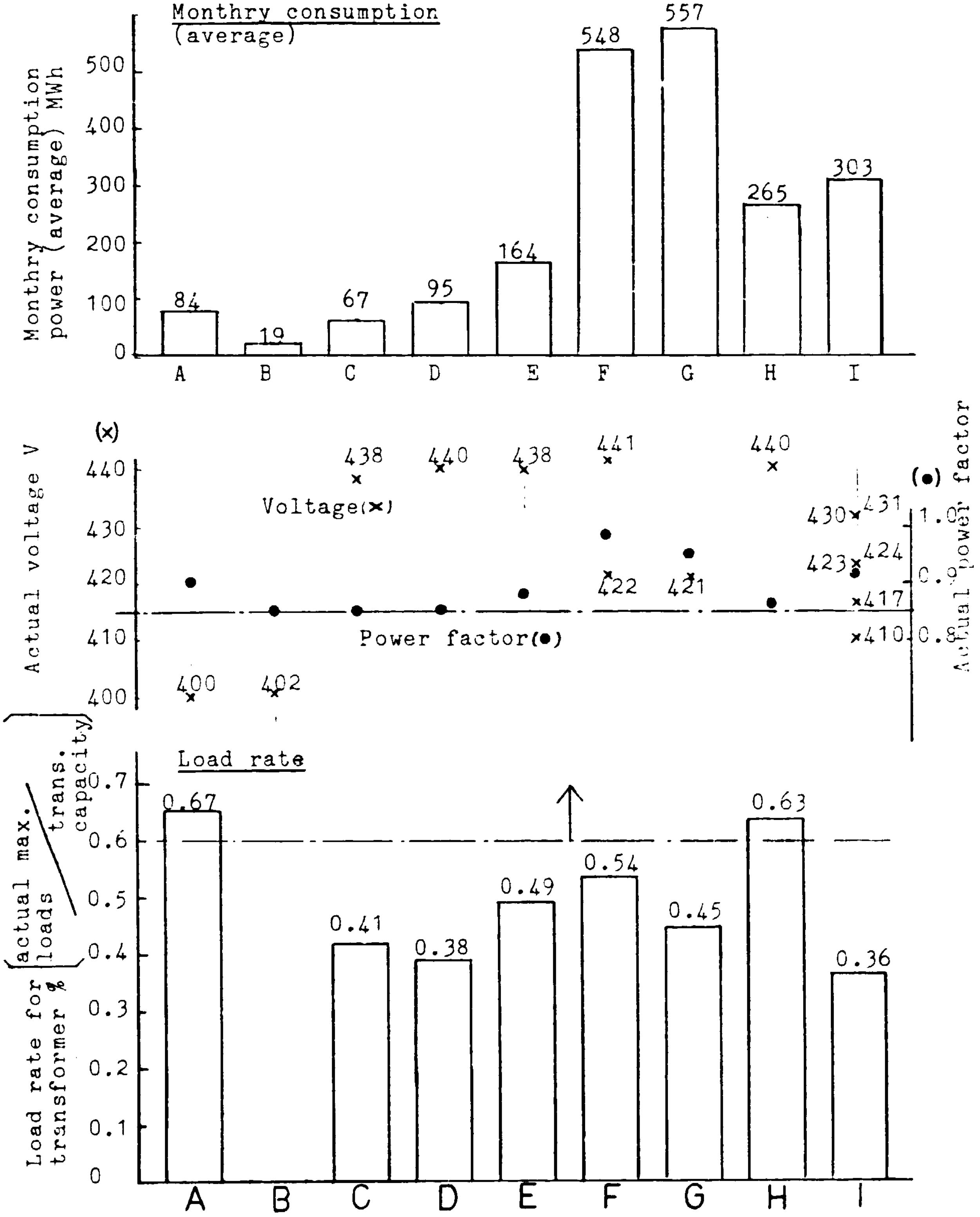
Electrical loading condition of various industrial groups are as shown in table 6.3.1..

Industrial groups	Products	Descriptions of major loads	Details of major loads: Power consumed (% of the total power)	Rating capacity of each motor (kW)	Remarks
Rubber	Shoes	Mixer, Crackers and Open roll mills.	50-52	75-93	Intermittent load, L.F* of motor is small
		Press and air compressor	20	30	Continuous loading, L.F* of motor is small
Ceramics	Tiles, Fire-brick	Crashers, Ball mills and blungers	15-30	44-60	Cont* loading(24Hrs), L.F* of motor is small
		Extruders and Press.	40-46	30-82	Cont* and intermittent loading. L.F* of motor is small
		Fans, blowers	12-40	30-60	Cont* loading(24Hrs)
Cement	portland cement	Mills(raw material and cement)	51	110 to 230	Cont* loading(24Hrs) L.F* of motor is good
		Kilns, Blowers and Exhauster	25	22-110	Cont* loading(24Hrs) L.F* of motor is good
		Air compressors. air-separators			Cont* loading(24Hrs) L.F* of motor is good
Textiles	Cotton Wool and other	Carding, Spining, Winding, Weaving Finishing	50-65	10-25	Cont* loading(24Hrs) L.F* of motor is good
		Air conditioning	25-46	200	Cont* loading L.F* is good
	Polyester	Extruding (including heaters)			Cont* loading L.F* is small
		Twisting	17	7.5-20	Cont* loading L.F* is small
		Roping and Netting	32	Less than 25	Cont* loading L.F* is good

* Cont. : continuous L.F : load factor

Table 6.3.1 <u>Electrical loading conditions of various industrial groups</u>

Utilized condition of electric power in various industrial groupe



Transformer capacity (kVA)	750		750	1000	750	2000	2500	1000	6100
Max. power (kW)	500	100	250	300	340	1000	950	550	1250

Recommendation of energy saving (electrical part I)

Factory	Energy management	Electric supply: transformer capacity (kVA)	Electric supply: voltage (V)	Electric supply: power factor (%) (actual)	Electric supply: others
A		present 750 .67 ↗ (load rate)	present 400 ↗ 420	0.90	
B		-	402 ↗ 420	0.85	
C		750 .40 ↘ 450 .65	438 ↘ 420	0.83	exchange static capacitor
D		1000 .38 ↘ 500 .75	440 ↘ 415	0.94	
E		750 .49 ↘ 500 .80	438 ↘ 420	0.88	static capacitor are hot
F	watch out light load of motor	2000 .54 ↘ 1500 .71	441 422 ↘ 400	0.93	
G	install demand controler	2500 .45 ↘ 1250 .89	421 422	0.95	improve unbalance of load currents
H		1000 .63	442 ↘ 420	0.86	exchange static capacitor
I	install demand controler	6100 .36 ↘ 3050 .70	410 - 430 ↘ 410	0.91	static capacitor temp. high improve unbalance
		6/8	8/9		

Recommendation of energy saving II (electric load)

Factory	Motor capacity and others	*Air compressor **Air conditioner	Electric heater	Lighting	Effect of improvements $/y	Effect of improvements % (kWh/y)
A	2x100 Hp motor are over estimate increase roling lots size	*let exhaust pressure down		let position of light down	336	0.2 (1461)
B		*let exhaust pressure down down temp. intake air			575	1.3 (2500)
C	extruder's motor are over estimate	*let exhaust pressure down			2157	1.2 (9378)
D	extruder, hydro-pump are over estimate	*let exhaust pressure down		there are plases with shot lux	1515	0.7 (6587)
E	presses motor are over estimate install static capacitor near presses motor			turn on stair's lamps	13300	2.0 (39856)
F	let supply voltage down require good maintenance	*down temperature intake air	exchange to fuel or waste gas	there are plases short lux	49574	3.1 (199137)
G	investigate light loads	**relocate dissipating equipments (compressor, capacitor)		there are plases short lux	11169	8.1 (37496)
H	some equipments motor are over estimate		bath heater exchange to steam or fuel	there is place short lux	115386	15.4 (550636)
I	some equipments motor are over estimate	**decrease air conditioner loads		there are places short lux	39032	4.0 (231187)

(1078 MWh/y)
4.3%

II. DIAGNOSTIC REPORTS ON INDIVIDUAL FACTORIES

MARCO SHOE SDN. BHD.

1. Outline of the Factory

Address: Pandamaran Industrial Site, Port Kelang,
Selangol, Malaysia

Capital: 3,000,000 Malaysian dollars

Type of industry: Rubber

Major products: Canvas/nylon footwear, rubber moulded products

Annual output: 2,500,000 pairs of shoes,
250,000 rubber mats

No. of employees: 516

Annual energy consumption:

- Electric power, 1,235,505 kWh
- Fuel, diesel oil, 263.7 kℓ

Interviewees: Mr. Ganesan s/o Arumugam, Factory Manager
Mr. Ho Hong Seng, Maintenance Superintendent & Electrical Engineer
Mr. R. Subramanian, Senior Supervisor
Mr. Gurmeet Singh, Senior Supervisor
Mr. Wan Idris Bin Jusoh, Mechanic Supervisor
Mr. K. Nalaian, Mechanic Supervisor
Mr. Wong Juan Foo, Electrician Supervisor

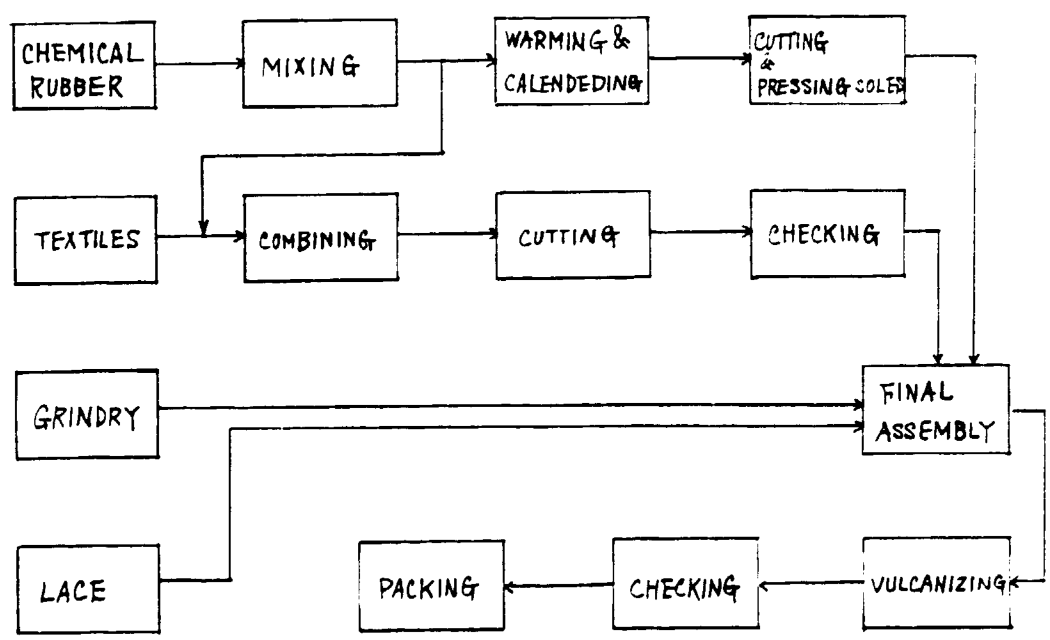
Date of diagnosis: Mar. 21 - 22, 1983

Diagnosers: Mr. M. Eguchi, Mr. R. Takahashi, and Mr. T. Sugimoto

Counterparts: Dr. Mohd Ariff Araff, Dr. Ong Peng Su, Dr. Radu, Mr. Ahmed Faizul, and Mr. Alizan Ab. Manan

- The factory is located about 8 km west of Kelang, an old capital of Serangon, which is situated about 32 km west of Kuala Lumpur.
- The factory has an integrated production facility to produce sport shoes and other rubber goods from the stage of raw rubber. Most of the products are exported.
- The energy consumption cost in the factory is 2.8% of the turnover, a relatively low figure. But, the managers of the factory have a great concern for energy-conservation. We could feel their great respect toward our diagnosis and surveys.

2. Manufacturing Process

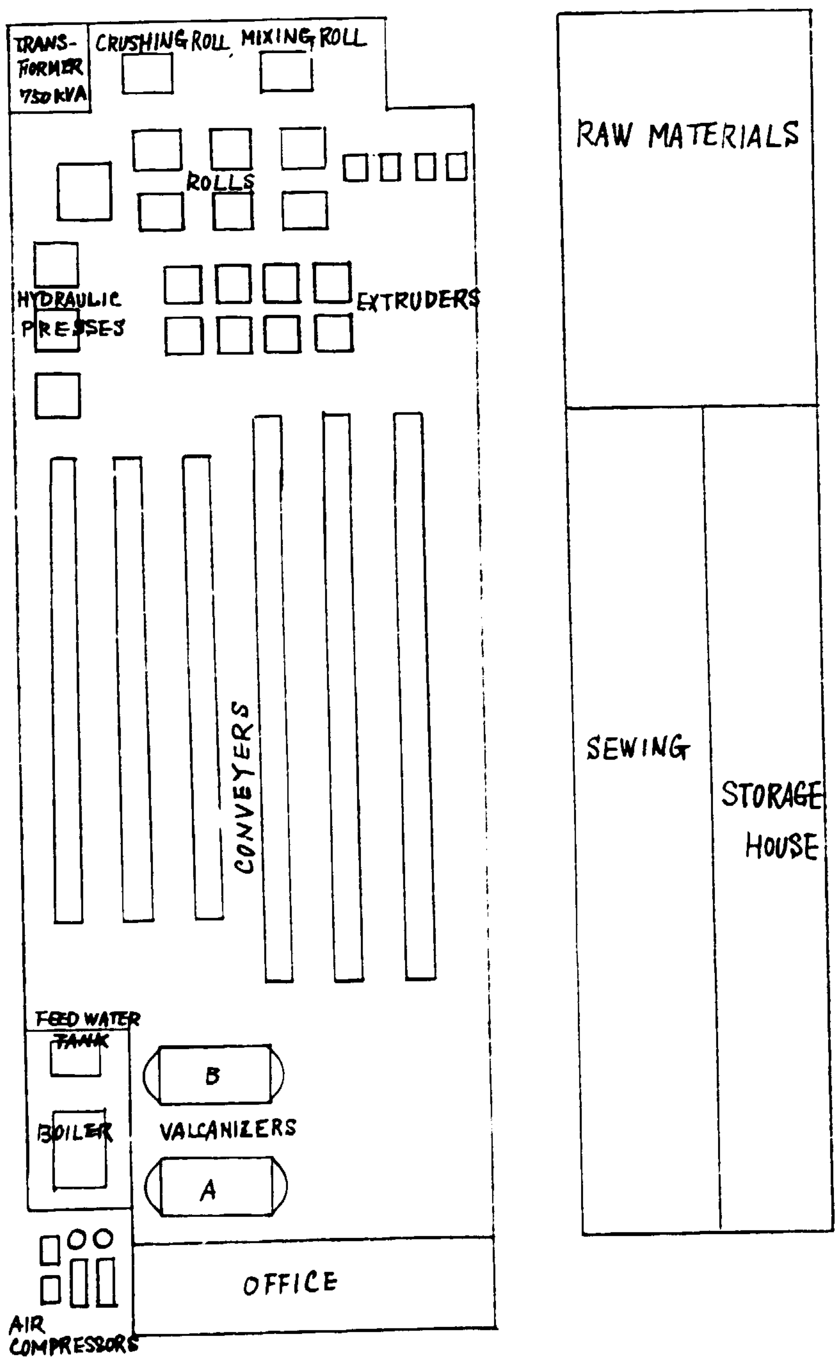


3. Major Equipment

3.1 Major Equipment

Name	No. of Units Installed	Type, etc.
Boiler	1	Steam pressure: 13 kg/cm^2 Rated evaporation: 1,600 kg/h
Vulcanizer A	1	Capacity: 840 pairs/charge Dia. 2.1 m x length 7.8 m Safe working press: 0.9 kg/cm^2
Vulcanizer B	1	Capacity: 840 pairs/charge Dia. 2.1 m x length 7.8 m Safe working press: 6.3 kg/cm^2
Hydraulic press	5	
Calendering roller	3	

3.2 Layout


TRANS-
FORMER
750 KVA
CRUSHING ROLL
MIXING ROLL
ROLLS
HYDRAULIC
PRESSES
EXTRUDERS
CONVEYERS
FEED WATER
TANK
BOILER
B
VALCANIZERS
A
AIR
COMPRESSORS
OFFICE
RAW MATERIALS
SEWING
STORAGE
HOUSE

4. Situation of Energy Management

- An energy-conservation committee was organized with the factory manager acting as chairman, and a maintenance superintendent as energy-conservation manager.
- A target is set to achieve a 3% energy-conservation per year. The factory received the guidance of a Malaysian energy consultant last year. A heat balance is in practice.
- As for the management of energy consumption, recording is made hourly on fuel consumption and daily on electric power consumption. The energy consumption rate is well understood.
- But, there is no control chart for an effective use of these data. No analysis of fluctuation factors is made.
- Many items are left unattended. To be more specific, there are problems such as the selection of sensors for thermometers, which sets the operating standard of an autoclave, is no good, or the steam pipes, particularly the flanges and valves, are not heat-insulated, or the boiler is just repeating the on-off, or the generated steam pressure is higher than what is necessary.
- Workers' cooperation is absolutely necessary in order to further promote the energy-conservation that has taken roots. But, a suggestion system for improvement, employees training or the factor manager's campaign to workers are not in practice.

5 Situation of Fuel Consumption

The data given by factory Manager was as follows ;

Diesel oil	2637 kl/year
Working days	250 day/year
Working hours	16 hr/day
Daily consumption of fuel	87.9 l/hr

This factory has a 100 hp. Wet-back Maxitherm boiler. Most of the steam is for the vulcanisation process, while the remainder, for forming presses and rollers

5.1 Boiler Operation

The measured and observed values of some of the essential parameters of the boil r were as follows ;

(a) Flue gas temperature	195°C
(b) O_2 content in flue gas	9.5 %
(c) Dispersion heat loss	11,590 kcal/hr
(d) Amount of blow-down	0.31 kg/kg of fuel
(e) Fuel feed rate	1.4 l/min

It is the most important step to prepare the heat balance sheet of the objective facility for diagnosis.
Using the above data, we can get the heat balance sheet to be able to recognize where and how much to spent the thermal energy as Table A.5.1.

Description	Input		Output	
	kcal/kg fuel	%	kcal/kg fuel	%
Input				
Fuel (Net)	9970	97.9		
Feed Water	220	2.1		

Output				
Flue gas			1151	11.3
Dispers'n Heat Loss			230	2.2
Blow-down			50	0.5
Steam (balance)			8759	86.0
Total	10190	100	10190	100

Table A.5.1 Heat Balance Sheet

5.2 Autoclave Operation

(1) According to the factory Manager, 70 % of the steam is consumed by the two autoclaves. The temperature measurement made on autoclave-B surface gave the following readigs ;

Cylinder	50 °C	(area 55 m^2)
Door	100 °C	(area 4.2 m^2)

(2) Heat content of Equipment

(a) Mass of autoclave-B was assumed as 20,000 kg.

Therefore, the heat content of the autoclave is

$$Q = 20,000 \times 0.12 \times (125 - 32)$$
$$=223,000 \text{ kcal/Batch}$$

where 0.12 is specific heat of steel in unit of kcal/kg.°C .

(b) Insulation Material

The insulation material has total mass of about 2,200 kg. Then the heat content of insulation material is as follows ;

$$Q = 2{,}200 \times 0.2 \times (125 - 32) \times 1/2 = 20{,}450 \text{ kcal/Batch}$$

where 0.2 is specific heat of insulation material and 1/2 is used becouse it is assured that 1/2 of insulation material is affected by the temperature difference.

(c) Total Heat Requirement in Start-up Operation

It is the sum of (a) and (b),

$$Q_T = 223{,}000 + 20{,}450 = 243{,}450 \text{ kcal/Batch.}$$

(d) Hot Loading

Once autoclave has started, the temperature vary between 125 and 80 ^oC for loaded and unloaded condition respectively. The heat requirement for the hot loading operation is calculated roughly as follows ;

$$Q_{T'} = 243{,}450 \times (125 - 80)/(125 - 32)$$
$$= 117{,}798 \text{ kcal/Batch}$$

(3) Heat Requirement of Content Material

(a) The shoe rack has a mass of about 2324 kg/Batch. The heat requirement is ;

$$Q = 2324 \times 0.12 \times (125 - 32)$$
$$= 25{,}936 \text{ kcal/Batch}$$

(b) The aluminium lasts have total mass of about 1,277 kg/Batch. The heat requirement is ;

$$Q = 1{,}277 \times 0.22 \times (125 - 32)$$
$$= 26{,}127 \text{ kcal/Batch,}$$

where 0.22 is the specific heat of aluminium.

(c) The shoes which consist of canvas and rubber have averagely the mass of about 554 kg/Batch.

Heat reqirement is ;

$$Q = 554 \times 0.4 \times (125 - 32)$$
$$= 20,609 \text{ kcal/Batch}$$

where 0.4 is the average specific heat of the shoe.

(d) The total heat requirement of the content material is, therefore,

$$Q_m = 25,936 + 26,127 + 20,609$$
$$= 72,672 \text{ kcal/Batch}$$

The heat requirement per batch operation of valcanization on the autoclave-3 is as in table A.5.2 ;

Description	Start-up from cold		Hot loading	
	kcal/Batch	%	kcal/Batch	%
Surface Heat Loss 1)	33,984	9.7	33,984	15,1
Heat content of Equipment	243,450	69.5	117.798	52.5
Heat requirement of content	72,672	20.8	72,672	32.4
Total	350,106	100.0	224,454	100.0

Note 1) ; Surface heat loss during any batches are assumed as constant.

Table A.5.2 Heat requirement in Valcanization Process.

Each autoclave is operated at rate of 4 batch a day. Assuming that autoclave-A carries out on similar operating cycles and heat requirements. Then the total heat requirements for two autoclaves per one day is as follows ;

$$Q_T = 350,106 \times 2 + 224,454 \times 3 \times 2$$
$$= 2,046,936 \text{ kcal/day}$$

(4) <u>Efficiency of Steam Consumption in Autoclaves</u>

The energy in the steam is 86 % of the total fuel input in boiler. The two autoclaves consume about 70 % of the steam produced. the energy value of steam supplied to the autoclaves is therefore ;

$$Q = 0.86 \times 10,190 \times 0.7 \times 71.4 \times 8$$
$$= 3,503,958 \text{ kcal/day}$$

where 10,190 ; Net fuel conbustion heat kcal/kg of fuel

71.4 ; Amount of fuel consumption per hour kg of fuel/hr

8 ; Working hours per day

The efficiency of autoclave is therefore ;

$$= 2,046,936/3,503,958$$
$$= 0.584 = 58.4 \%$$

6. Problems in Thermal Energy Utilization and their Potential Solutions

6.1 Boiler Operation

(1) O_2 Control in Exhaust flue gas

If the O_2 content were reduced to 5 %, the fuel saving would be as follows ;

Description	Observed	Improved
O_2 content in flue gas (%)	9.5	5.0
Air-ratio	1.83	1.3
Flue gas Vol. (Nm^3/kg fuel)	21.41	15.47
Heat loss influe gas (kcal/kg fuel)	1151.0	832.0

The saved heat ΔQ would be ;

ΔQ = 1151.0 - 832.0 = 319 kcal/kg of fuel

which is equivalent to the amount 3.2 % of fuel input in the boiler.

The saving in fuel due to this reduction would be ;

$\Delta\$$ = 121,000/year x 0.03 = \$3630/year even with the flue gas temperature of 195 °C.

(2) Boiler Water Quality Control

The boiler was not equipped with PH. and Electric Conductivity Meters. The blow-down operation is generally carried out accoriing to reference of water quality. With the suitable blow-down operation the savings obtained would be about 0.5 % in Maximum of total energy input on boiler.

(3) Feed Water Meter

It should be equipped to correctly monitor the quantity of water entering boiler which is equivalent to produced steam. In this survay the amount of produced steam has been estimated through the balance which is calculated by substruction the total heat loss from the input energy.

6.2 Steam Consumption

(1) Autoclave Operation

The loading and unloading operation of each autocrave takes place about one hour by one hour. This resulted in large heat losses and decrease of boiler loading factor. It would be better to operate the autoclaves on continuous basis so that the heat losses would be reduced and the boiler fully utilized.
To reduce the unloading period, it is suggested to be fully ready to charge the new batch material before unloading the contents in the autoclaves.

(a) Door Operation

In present, the door of autoclave is keeping on openning until next operation. It cause the waste energy. Then after unloading the door should be closed to prevent to cool down the autoclave until being ready on the next loading.

(b) Door Insulation

If the measure for the door insulation is only carried out, the heat loss would be reduced by 3,000 kcal/hr.

Assuming that fuel unit cost is $ 0.054/1000 kcal and working hours per year is ;

250 day/year x 12 hrs/day = 3000 hrs/year.

Saving with two autoclave is as follows ;

= 3,000 x 0.054/1,000 x 3,000 x 2

= $ 972 /year.

(2) <u>To insulate the Press machines</u>

According to the factory Manager, the press machines consume about 25 % of the total steam generated.

The recomended are as folloes ;

(a) <u>The enclosures placed around the press machine</u>

With reference to Japanese experience such measure would save 25 % of energy originally required by the press machine. The savings would be able to calculated as follows ;

Saved Heat = 8,759 x 71.4 x 8 x 0.25 x 0.25

= 312,700 kcal/day

Saving = 312,700 x 0.054/1000 x 250

= $4220 /year

(3) <u>To insulate the Boiler Feed-Water Tank</u>

The feed-water tank which was bare should be insulated to reduce surface heat losses. The dispersion heat from the feed-water tank was measured to be about 8,400 kcal/hr which was equivalent to about 1.0 litre/hr of fuel. The annual saving octained by proper insulation of the feed-water tank would be as follows ;

= 8,400 x 8 x 0.054/1000 x 250

= $ 840/year

(4) To insulate the Drain Recovery Pipe

The drain recovery pipe lines from the autoclaves and the press machines have no insulations which resulted in heat losses. Especially it would be effective to insulate the drain pipe lines of autoclave which consist of 50 mm of diameter and about 50 m of length.

According with the insulation of this pipe line, the amount of saving energy, 10,000 kcal/hr are achieved.

The saving annually would be as follows ;

= 10,000 x 0,054 x 8 x 250

= $ 1,000 /year

7. Electricity

7.1 Electrical consumption characteristics.

- supplier : National Electricity Board of States of Malaya.
- contractual maximum demand : 500 kW
- average monthly consumption : 84.4×10^3 kWh
- factory load factor : 67.0 %
- contractual power factor : 0.9
- transformer capacity : 750 kVA
- rated supply voltage : 415 Volts

7.2 Schmatic diagram and outline of factory.

Electrical schematic diagram is as shown in Figure 7.1.

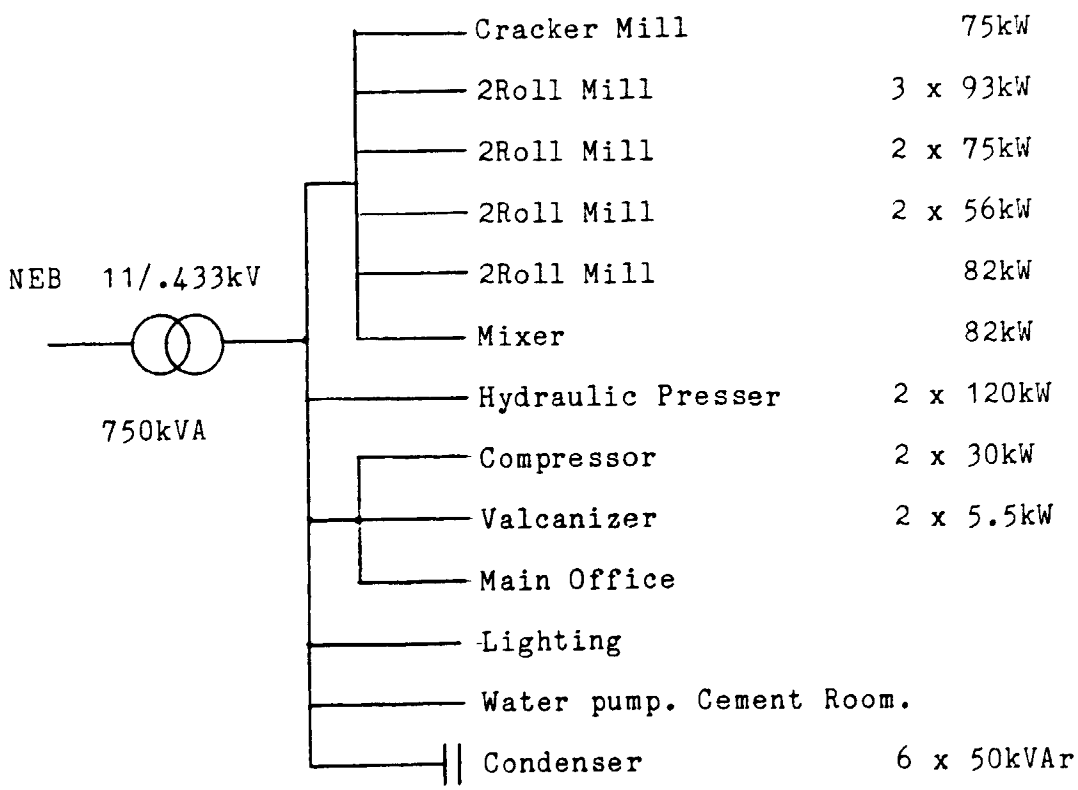


Figure 7.1 Electrical schematic diagram of MARCO SHOES BHD.

The factory main loads are;

(a) nine open roll mills of total capacity of 724 kW.

(b) two large air compressor and some hydraulic pumps of 120 kW.

All factory loads are connected to a 750 kVA, 3 phase transformer with metering's on the low voltage side.

8. Problems in electric power utilization and their potential solutions

8.1 Source

8.1.1 Transformer

The source is connected to a 750 kVA, 3 phase transformer. The average loading is 430 kW (467 kVA assuming a 0.9 power factor) of which 50 % is utilized by the large open roll mills and 40 % by other equipments in the factory. The remaining 10 % is for lighting and air conditioning.

In our opinion the transformer is optimum size. However the operation of the large open roll mills create considerable fluctuation to the input power.

8.1.2 Operation voltage

From the name plate of the motors, it was found that the following specified voltage rating were connected, i.e, 400, 420 and 440 volts. Actual measured value of supply voltage is 400 volts. In this respect it is desirable to operate the factory with supply voltage of about 420 volts. This action requires that transformer tapping to be increased to the proposed voltage. This measure will reduce motor losses and improved torque. In future, it is also suggested that for new installations motor rating should be confined to 420 volts only.

8.1.3 Phase balance condition

Actual unbalanced in phase current of about 10% was detected. This is an undesirable condition because an unbalansed current would create an unbalanced supply voltage which in turn create negative torque in most three phase motors. Therefore effort is required to redistribute some of the single phase loads.

8.2 Electrical loads

8.2.1 Large motors

The large motors especially the open roll mills are required to drive high inertia rollers and also variable torque loads, creating large input current variation which make measurements very difficult. Therefore for all purposes considered an estimated average value is used in the calculation. Details of large motor loads are as follows;

Description	Motor rating(kW)	Quantity	Consumption(kW)	
			idle power	loades power
Cracker	75	1	0.7	40
Open roll mill	93	3	3x5.5	3x57
Open roll mill	75	2	2x7.0	2x16
Open roll mill	56	2	2x3.0	2x50
Open roll mill	82	1	5.0	55
Mixer	82	1	4.0	44
TOTAL	780		52.5	492

Table Large motors loads

As indicated earlier many of the large open roll mills have erratic load pattern and intermittent stop/start characteristic. From the table above the maximum total power consumed by these motors is 492 kW while the idled power is only 53 kW. It was further observed that an average 75% of their working time the open roll mills were idling. This gives us the conclusion that the optimum size for either the motors or the main-intake transformer can be much smaller than the maximum specified load as indicated by the following formula;

$$P = \sqrt{\frac{53^2 \times 1.0 + 492^2 \times 0.25}{1.25}} = 225 \text{ kW}$$

P as calculated gives the theoretical combined optimum size of the open roll mills motor. The value of P which a reasonable safety factor of about 25% would give the combined optimum size of the open roll mills motor required.

However large motors made up half the total factory load and the remaining load of the factory are considered constant (i.e non-variable). Therefore the actual transformer rating required can be calculated as follows (assuming a p.f of 0.9);

$$\text{Required transformer rating} = \frac{225 \times 1.25}{0.9} \times 2 = 625 \text{ kVA.}$$

The present transformer as stated earlier is 750 kVA thus giving a load factor of 0.83 which as explained earlier to be of optimum size.

From the measurements obtained it was observed that the 2 open roll mills rated 75 kW were overdesigned. Our culculation indicated that motors of rating 50 kW would be sufficient. The saving below can be realized if the two 75 kW motor were changed to 50kW

(75-50) kW x 0.13 x 0.3 x 3.0 x 250 x0.32 x 2
=$336 / year

where, 0.13 : the loss factor
3.0 : iron loss factor
3.0 : working hours per day
250 : working day per year
0.23 : the electricity tariff 'i.e' 23 cents/kWh

8.2.2 Fly wheel effect

Each open roll mill has two huge rollers which have inertia (fly wheel effect) resulting in erratic motor load. This requires countermeasures in the following two areas;

(a) It is desirable to achieve a continuous loading of the rollers so that frequent stop/start operations of the rollers can be avoided or reduced by increasing of material lot-sizes.
(b) The material once placed in the rollers are continuously being rolled even though they are ready for the next process. Therefore an automatic cutter should be employed to reduce wasteful extra rolling operation.

8.2.3 Compressed air system

It was noted that the Valcaniser (autoclave) requires compressed air of pressure 3 kg/cm^2 . However the pressure delivered by the compressors was 7.2 kg/cm^2. This difference in pressure is too large. Normally a 1kg/cm^2 pressure difference is sufficient. Nevertheless other equipments pressure, requirements could not be determined. Therefore it is advisable to lower the compressed air pressure in stages to suit the complete factory requirements. If it was found that the air pressure requirements of the pressers are much higher than the autoclave, then a separate compressor for the pressures is recommended.

8.2.4 Lighting

Generally the lighting in the main factory is reasonable. In the sewing section the existing lighting intensity on the working surfaces is around 200 lux. It is recommended that the lighting fittings in this section be lowered by 0.3 meter to achieve an intensity of 300 lux. This value is sufficient for this nature of work, thus improving the efficiency and quality.

9 Summary

9.1 Thermal Part

The effective measures on the thermal energy conservation are summerized as follows ;

(1) 1st. Phase Measure (No or little investment)

	Annually fuel saving %	Annually fuel saving $
(a) Air ratio inprovement to reduce O_2 from 9% to 5%	3.2	3,630
(b) Inprovement of Autoclave Performance	Guessed value about 10.0	-

(2) 2nd. Phase Measure (Some investment)

	%	$
(a) Insulation of drain-return lines from autoclave		1,080
(b) Insulation of boilor feed tank		840
(c) Insulation of door of autoclaves		972
(d) Case cover insulation of Pressing machine	about 25% of present consumption	

9.2 Electrical part

On the electrical side there are not many recommendations where improvement to energy saving could be substantial except;

(1) In section 8.2.1. where a reduction in overall size of the two 75 kW open roll mill motors could realized a saving of $336/year.

(2) In section 8.2.3 where the reduction in compressed air pressure could realized a saving of about 3 % for each kilogram pressure reduction.

(3) The stop / start operations should be avoided. However the saving could be substantial but could not be quantified at this stage.

USMETA SDN. BHD.

1. Outline of the Factory

Address: No. 2 Lorong Enggang Empat, Taman Keramat,
Kuala Lumpur

Capital: 2,800,000 Malaysian dollars

Type of industry: Rubber

Major products: Retreated tyres

Annual output: 36,000 t

No. of employees: 33

Annual energy consumption:

- Electric power, 223,390 kWh
- Fuel, diesel oil, 186 kℓ

Interviewees: Mr. Zainuddin Fathodin, Factory Manager
Mr. Mohd Basir Biw Majid, Account Executive
Mr. Ismail Bin Yassin, Production Executive
Mr. Gan Boon Hui, Marketing Executive
Mr. Ali Bin Ahmad, Fitter & Foreman

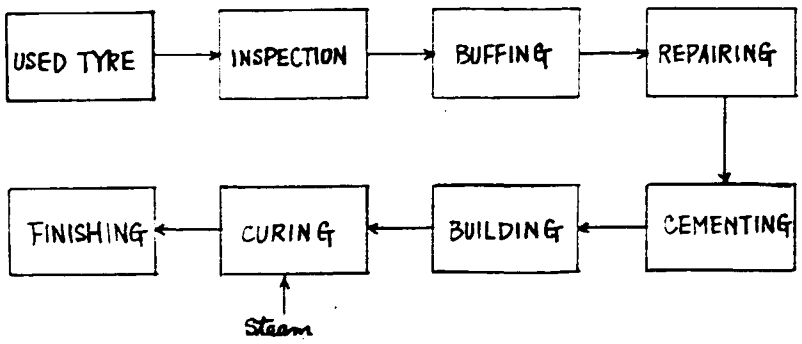
Date of Diagnosis: Apr. 18 - 19, 1983

Diagnosers: Mr. M. Eguchi, Mr. R. Takahashi, and
Mr. T. Sugimoto

Counterparts: Dr. Mohd Ariff Araff, Dr. Ong Peng Su,
Mr. Ahmed Faizul, and Mr. Arizan Ab. Manan

- This is a factory to produce retreated tyres, belonging to the MARA group established in 1972. The factory is located about 7 km east-northeast from the center of Kuala Lumpur.
- It is a small factory employing 33 persons. But, it is relatively large among tyre retreating factories that count about 200. The company's share in the Malaysian market is about 5 - 6%.

2. Manufacturing Process

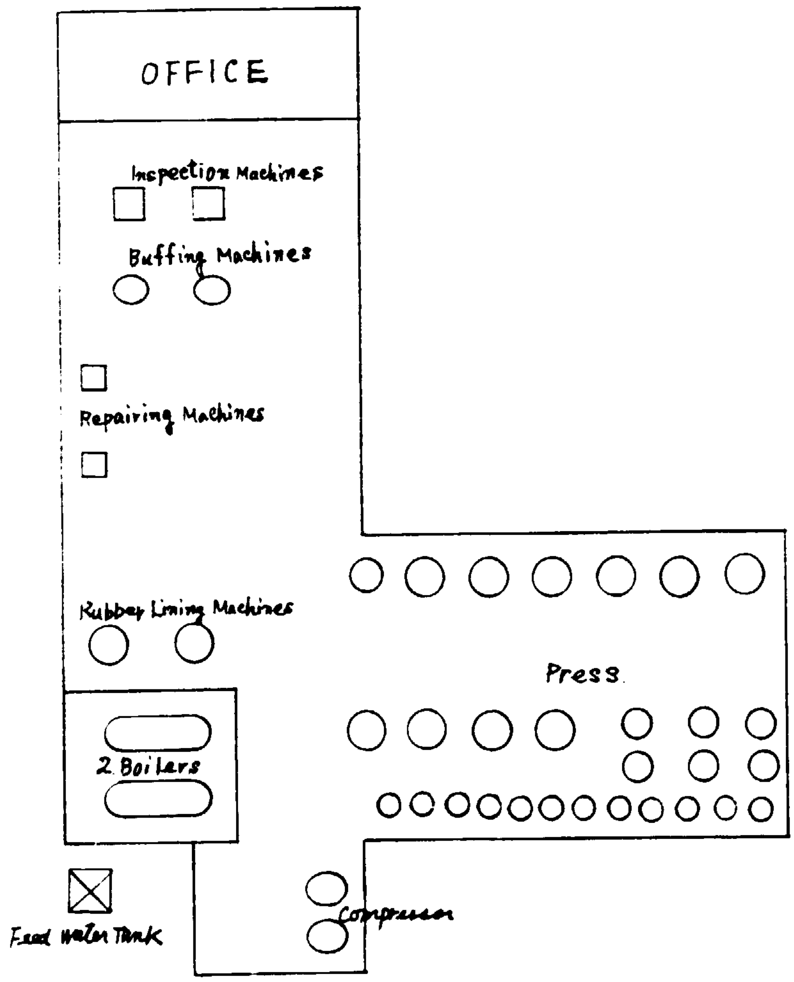


3. Major Equipment

3.1 Major Equipment

Name	No. of Units Installed	Type, etc.
Curing machine		
Large size press	10	No. of new type: 4 No. of old type: 6 Steam consumption: 18 - 20 kg/h Steam pressure: 5 kg/cm^2
Small size press	18	No. of new type: 6 Steam consumption: 10-13 kg/cm^2 Steam pressure: 5 kg/cm^2 No. of old type: 12
Boiler	2	Steam pressure: 10.5 kg/cm^2 Rated evaporation: 2,268 kg/h
Compressor	1 1	30 HP, 12 kg/cm^2 25 HP, 12 kg/cm^2

3.2 Layout


OFFICE
Inspection Machines
Buffing Machines
Repairing Machines
Rubber Lining Machines
Press
2 Boilers
Feed Water Tank
Compressor

4. Situation of Energy Management

- The energy cost to the turnover is relatively small and the scale of operations is small. It may be for this reason that no organization or system has been created to promote energy-conservation. There is no worker training program or a PR activity.
- From the point of the company's activities as well as its scale of operations, the company feels it unnecessary to employ technical staff. All equipment and technical matters are left to a fitter-foreman. From time to time, the factory manager checks on steam trap, etc. himself.
- All of the steam condensated from curing is fed back to the feed water tank by a semi-closed condensate recovery type. This is very good from the point of recovery of exhaust heat. But, the drain pipe should be heat-insulated even though it is for exhaust heat.
- The burning of fuel is repeated through the on-off operation at a short pitch of 5 - 7 minutes. This means a big loss of energy. The steam work schedule, steam pressure and the burner nozzle, etc. should be studied so that a continuous burning can be performed by reducing the frequency and shortning the period of the off operation.

5. Situation of Fuel Consumption

(1) Terms of Fuel

(a) Amount of fuel supply 10,900 litre/3 weeks

(b) Net Heating Value of Fuel

The net heating value of the fuel is calculated as follows ;

$$10,891 - 600(9 \times 0.14) = 10,135 \text{ kcal/kg of fuel}$$

where 0.14 is the wt. % of H molecule in H_2O, 600 kcal/kg is the rough latent heat of vaporization of H_2O and 9 is the ratio of H_2O to H_2 in weight, 18/2.

(c) Energy Input per hour to the Boilor

Based on the fuel consumption rate and the net heating value of fuel, the heat energy input to the boilor is as follows ;

$$93.7 \times 10,135 = 950,000 \text{ kcal/hr}$$

(2) Terms of Boiler Operation

(a) Actual Working Hours

Working hours from Mon. to Fri. were 12 hrs and on Sat. were 9hrs. The total hours for 3 weeks were ;

$$(12 \times 5 \times 3) \div (9 \times 3) = 207 \text{ hrs.}$$

This values corresponded to the amount of hrs for fuel supplying period to the factory.

(b) The cycle of operation

The cycle of operation has been observed as follows ;

Full firing 5 min.

Half firing 15 sec.

Fire stop 5 min. 30 sec. (incl. purge 30 sec.)

One full cycle observed was 10min. 45sec. of which the firing time was 47.2 % and the no-firing time with purging time was 52.8 % of the cycle.

(c) Actual Fuel Consumption

Based on the operation cycle and corresponding fuel supply data, the fuel consumption was estimated as follows ;

10,900 x 0.84/207 x 0.472 = 93.7 kg/hr

where 0.84 is specific gravity of fuel and 0.472 is the potion ratio of firing time in operation.

5.1 Boiler Operation

We must notice that the boiler disperse the heat with natural drafting during the non-firing part of the cycle. The boiler operation cycle of firing, purging and non-firing is illustrated below ;

5.1.1 Data of Cycle on Boiler Operation

Description	Time min	O_2 %	Temp. °C	Linear Velo. in Duct m/sec
Full Firing	5	9	240	-
Stop Firing	5	21	200	1.5
Purging Blow	0.5	21	200	-
Half Firing	1/4	-	220	-

Table B.5.1 Combustion Cycle

5.1.2 Heat Balance for Boiler Operation

The heat balance for boiler operation in terms of kg of fuel is shown in Table B.5.2 below ;

Description	Input		Output	
	kcal/kg of fuel	%	kcal/kg of fuel	%
Input				
Fuel	10135	93.0		
Feed Water (hot charge)	762	7.0		
Output				
Flue gas Heat Loss (during firing)			1429	13.1
Flue Gas Heat Loss (non-firing)			210	1.9
Blow-down			83	0.8
Dispersion heat Loss			196	1.8
Produced Steam (from Balance)			8979	82.4
Total	10897	100.0	10897	100.0

Table B.5.2 Heat Balance Sheet for Boiler

5.2 Steam Consumotion

5.2.1 Reauired Heat

The theoretical reauired heat is the sum of the heat content of the cured rubbers and some heat for vulcanization processes. Actually the later heat was omitted because of relatively small value in comparing to another much heat loss.

(1) Tyre Mass

Big Tyre	60 kg/piece
Small Tyre	30 kg/piece

(2) Number of Batch Processes per day

	No. of Mach.	Batch/day	Total No.
Big one	10	7	70
Small one	6	16	96

(3) Summary of reqired Heat per day

big one ; 60 x 0.25 x (180 - 30) x 70 = 157,500 kcal

Small ; 30 x 0.25 x (180 - 30) x 96 = 100,000 kcal

Total = 257,500 kcal

where 0.25 is specific heat of rubber and
180-30 is the temperature difference between steeam and ambient.

This value is corresponding to only about 2.6 % of the heat energy supplied by steam.

5.2.2 Heat loss

(1) Dispersion Heat Loss from Surfase of Curing Machine

The curing machines have complicated structures and shapes and then the surface areas were roughly estimated that the big one is 5 m^2 and the small one is 3 m^2.

The calculated dispersion heat loss are as follows ;

Big one ; 5 x 300 x 10 x 12 = 300,000 kcal/day

Small ; 3 x 300 x 6 x 12 = 108,000 kcal/day

Total = 408,000 kcal/day

where 5 and 3 are the estimsted surface areas in m^2,

300 is the observed dipersion heat flux kcal/m^2.hr,

10 and 6 are the no. of the curing machines and

12 is the mean working hours perday.

(2) Heat Content of Curing Machines

During unloading of the tyres from the curing machines the surface of machines are completely exposed to ambient. So, the temperature of machines is assumed to become to ambient. The heat content of thecuring machines to be heated from 30 to 180 °C is calculated as follows ;

Machine size		Weight kg	Heat content kcal/batch
Big	Steel	1000	1000 x 0.12 x (180 - 30) = 18,000
	Al	200	200 x 0.22 x (180 - 30) = 6,600
			Total = 24,600
Small	Steel	600	600 x 0.12 x (180 - 30) = 10,800
	Al	150	150 x 0.22 x (180 - 30) = 4,950
			Total = 15,750

where 0.12 and 0.22 are the specific heat of steel and aluminum respectively and the weight of material is the guessed value.

The heat content for machines per day is as followa ;

Big one 24,600 x 10 x 7 = 1,722,000 kcal/day

Small one 15,750 x 6 x 16 = 1,512,000 kcal/day

Total = 3,234,000 kcal/day.

Being compared to the heat available from steam which is 8979 kcal/kg fuel x93.7 kg fuel x 12 hr/day = 10,096,000 kcal/day , the percentage of energy required by the curing machines is about 32 %.

5.2.3 Heat Balance of Curing Operation

The heat balance in terms of kcal/day is as follows ;

Description	Input		Output	
	kcal/day	%	kcal/day	%
Input Heat from steam	10,096,000	100.0		
Output Heat up of Rubber for Curing			257,500	2.6
Dispersion Heat Loss			408,000	4 0
Heat Content of Curing Machines			3,234,000	32.0
Condensate for above Heat			1,098,000	10.9
Uncountable Heat			5,098,000	50.5
Total	10,096,000	100.0	10,096,000	100.0

6 Problems in Thermal Energy Utilization and their Potential Solutions

6.1 Boiler

The O_2 content in the flue gas could be reduced from 9 % to 5 % and the flue gas temperature could be degreed from 250°C to 180°C. In addition to these measures, the boilor should be operated continuously. The amount of energy saved by all these measures is 9.6 % of total heat supplied, in detail,

3.0 % is saved by reducing O_2 content

4.7 % is saved by reducing flue gas temperature and

1,9 % is saved by continuous boiler operation.

This factory used to spent about $ 94,000/year for fuel based on 10,00 litre/3 weeks and $ 0.054/1000 kcal. Then this factory would have a chance to save the fuel cost by conductng the above measures as follows ;

O_2 content	$2800
Flue gas temperature	$4400
Continuous operation	$1800

6.2 Steam Consumption Facilities

According to the heat balance, the large mount of uncountable heat loss which comprises of about 50 % of the total heat available from steam would probably be due to leakage through the steam traps. The return condensate has been mixed with raw steam, because the water in in the feed-water tank to which the condensate is returned back was about 100°C, Boiling state of water.

This drain recovery system extremely is unusual comparing to the normal one.

The leakage might has originated from defective steam traps which should promptly be checked. If the leakage from steam traps were avoided, about 20 to 30 % of the inputed steam could be saved. As cost, about $20,000 would easily be saved with the severe "house-keeping" and a small investiment.

7. Electricity

7.1 Electrical consumption chracteristic

- supplier : National Electricity Board of the States of Malaya.
- contractual maximum demand : 100 kW
- average monthly consumption : 18.6×10^3 kWh
- contractual power factor : 0.85
- rated supply voltage : 415 Volts

7.2 Schematic diagram and outline of factory

Electrical schematic diagram is as shown in figure 7.1.

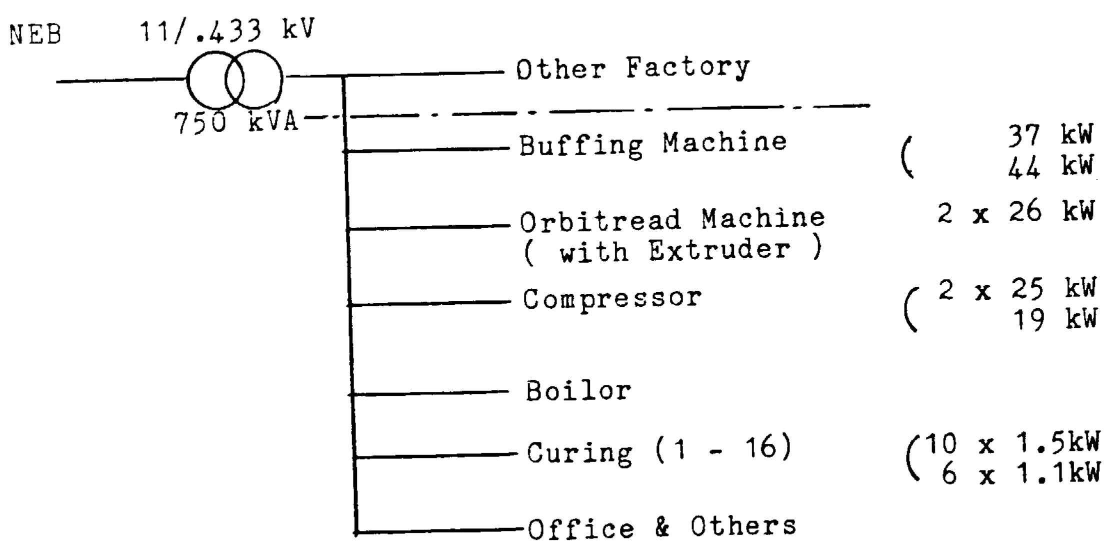


Figure 7.1 Electrical schematic diagram of USMETA SND BHD.

The factory main loads are;

(a) buffing machine of total capacity of 81 kW.

(b) compressor of total capacity of 69 kW.

(c) Orbitread machine of total capacity of 52 kW

All factory loads are connected to a common 750 kVA, 3 phase transformer which also supply neighbouring factory. Meterings are at 415 volts on the factory distribution board.

8. Problems in electric power utilization and their potential solution.

8.1 Source

It was observed that the incoming switch board compartment is permanently water-logged. This is a dangerous condition, where accidents can happen during both switching and maintenance. In addition to this, the condition of the switchboard and the associated wirings are in poor condition. It is highly recommended that measures should be taken immediately to keep the switch board room completely dry.

The input voltage as measured was about 402 volts while all the equipments are rated between 380 volts to 440 volts. The specified input voltage is not suitable and it is suggested that the input voltage be raised to 420 volts, to reduce losses and improve torque.

8.2 Electrical loads

8.2.1 Large motors

The main loads are for buffing and orbitread equipments and these machines are reasonably loaded with load factor varying between 0.62 to 0.67.

8.2.2 Compressors

There are three compressors where one is always on standby, compressed air are almost exclusively used by the curing machines, which require compressed air of pressure around 12 kg/cm^2 . This pressure requirement is considered high and therefore the piping need constant checking for potential leak. It is therefore recommended that measuring of charge and discharge time at between lower and upper limit level of compressed air pressure.

For the other equipments that require lower pressure compressed air, it is recommended that pressure reducing value be installed at the accumlator to reduce leakage and wastage. At the curing equipments where the pressure requirement is around 12 kg/cm^2, it is recommended to install stop valve. The purpose of the stop valve is to maintain the high pressure at the curing machines when the machines have warmed up such that the buck pressure from the curing machines are not fed back to the compressor, thus unnecessary burdening of the compressor can be avoided.

It is generally accepted fact that the air intake temperature of the compressors should be as low as possible for better efficiency. It was observed that temperature of intake air is around 38 °C. If the temperature of the intake air can be reduced by placing the compressors outside the factory with suitable shed and good air circulation for cooling, considerable energy can be saved. Assuming the external ambient temperature is 28 °C the possible saving of $575/year can be realised following the culculation below.

$$\frac{\Delta P}{P} = \frac{(273+38)-(273+28)}{(273+38)} = 0.032$$

where $\frac{\Delta P}{P}$ is the percentage saving in power

Therefore the average saving per year

= 31 kW x 0.032 X 12 x 300 x 0.23 x 0.7 = $575/year

where 12 : the working hours/day

300 : the working days/year

0.23 : the cost of electricity/kWh

0.7 : the working factor

9 Summary

9.1 Thermal Part

The effective measures on the thermal energy conservation are summerized as follows ;

(1) 1st. Phase measures (No or a little investment)

(a) Boilor Operation

	Annually fuel saving %	Annually fuel saving $
i) to reduce O_2 content	3.0	2,800
ii) to reduce flue gas temp.	4.7	4,400
iii) to keep on continuous Oper.	1.9	1,800

(b) Recheck on the Running Steam traps

	%	$
with rough estimation	20 to 30	20,000

(2) 2nd. Phase Measures (Some investment)

(a) Insuration of drain-return piping from all the curing machines	-	-
(b) Case cover over curing machines	About 25% of present steam consumption	

9.2 Electrical parts

On the electrical side the avenues for energy saving is rather limited with the exception of the compressors where some improvements requiring no investment have been suggested in section 8.2.2.

GOH BAN HUAT POTTERY WORKS SDN. BHD.

1. Outline of the Factory

Address: 238 Jalan Segambut, Kuala Lumpur

Type of industry: Ceramic

Major products: Sanitary wares, sewer pipes

No. of employees: 153

Annual energy consumption:

- Electric power, 3,500,000 kWh
- Fuel, fuel oil, 1,440 kℓ

Interviewees: Mr. Goh Taiseng, Managing Director
Mr. Vernon Perera, Plant Manager

Date of diagnosis: Mar. 25 - 26, 1983

Diagnosers: Mr. M. Eguchi, Mr. R. Takahashi, and Mr. T. Sugimoto

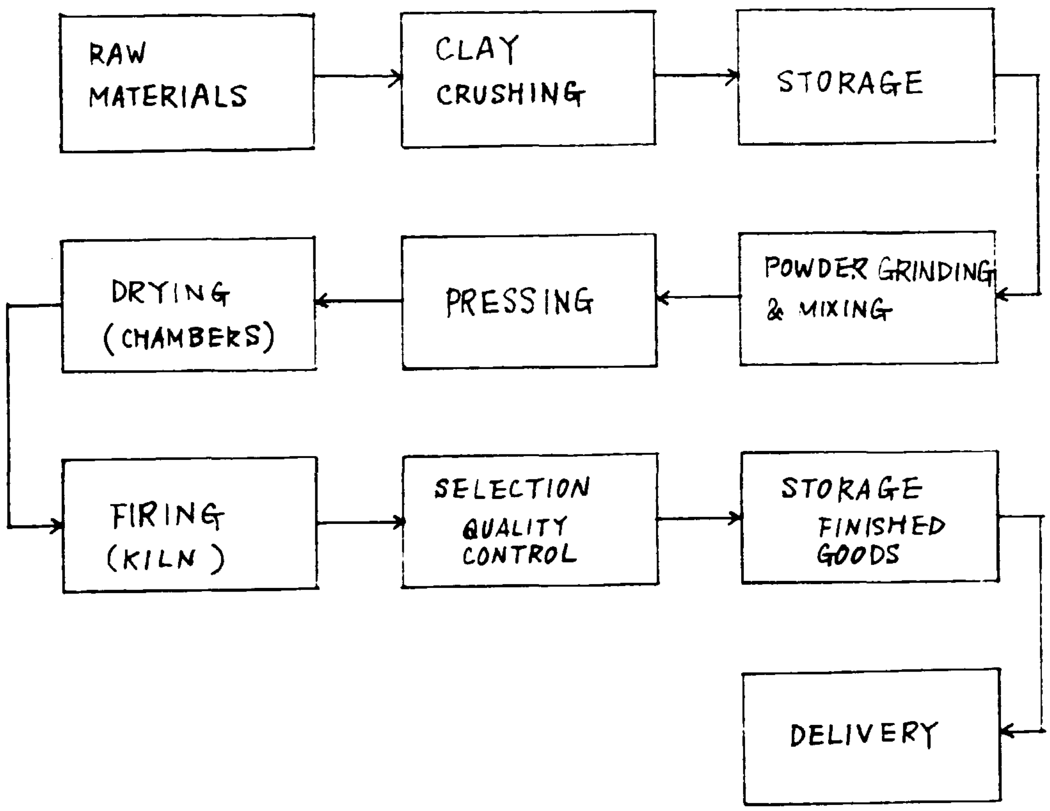
Counterparts: Dr. Mohd Ariff Araff, Dr. Ong Peng Su, Dr. Radu, Mr. Ahmed Faizul, and Mr. Arizan Ab Manan

. The factory is located about 5 km northwest of Kuala Lumpur.

. In the old factory where an electric batch type kiln installed in 1962 sanitary wares are produced. In the new factory where a batch type kiln fueld by diesel oil and automatic forming machine were installed in 1979 and 1982 respectively, sewer pipes of 6" - 12" diameter are produced.

- The company plans to stop the production of sanitary wares in the old factory, and concentrate on the production of sewer pipes in the new factory.
- At the request of the company we conducted our energy-conservation diagnosis only in the new factory where sewer pipes are produced.

2. Manufacturing Process

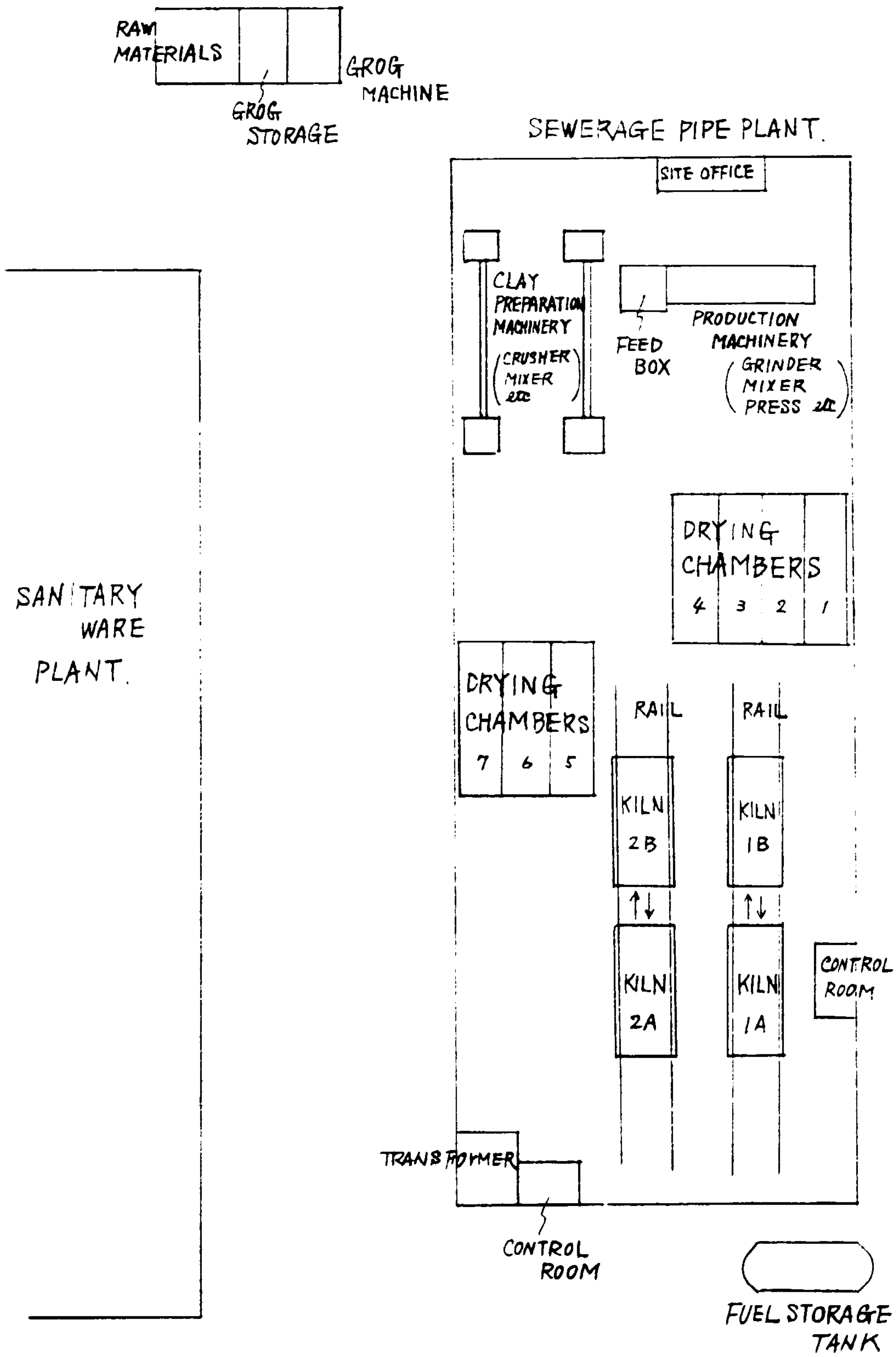


3. Major Equipment

3.1 Major Equipment

Name	No. of Units Installed	Type, etc.
Oil fired kiln	2	Batch type, Capacity: 50 T/batch Max. temperature: 1,160°C Products: Sewer pipes
Drying chamber	7	
Electric kiln		Batch type, Products: Sanitary wares

3.2 Layout


RAW MATERIALS
GROG MACHINE
GROG STORAGE
SEWERAGE PIPE PLANT.
SITE OFFICE
CLAY PREPARATION MACHINERY
(CRUSHER MIXER etc)
FEED BOX
PRODUCTION MACHINERY
(GRINDER MIXER PRESS etc)
DRYING CHAMBERS
4 3 2 1
SANITARY WARE PLANT.
DRYING CHAMBERS
7 6 5
RAIL
RAIL
KILN 2B
KILN 1B
KILN 2A
KILN 1A
CONTROL ROOM
TRANSFORMER
CONTROL ROOM
FUEL STORAGE TANK

4. Situation of Energy Management

- There is no organization or system for the promotion of energy-conservation. Nor, there is any target set for the purpose. There is no employee training and PR activity in practice.
- As for the heating/cooling pattern, which is extremely important in operations, work is conducted according to the work standards established on the basis of the standard temperature curve.
- The electric power consumption is known through the monthly bill for the whole factory. As for fuel consumption, a continuous recording of temperature is done at 6 points in chambers besides the reading of fuel flow meters. These records are kept in order together with other records of operations. But, there is no data analysis done through the calculation of energy consumption rate and the preparation of a control chart.

5. Situation of Fuel Consumption

5.1 Shuttle Kiln Operation with Batch Process

(1) Standard Operation Data

The standard operational data in the shuttle kiln for the manufacturing raw sewerage soil pipe are mainly as follows ;

(a) Manufacturing Cycle

Heating and calcination period	36 hr/batch
Cooling period	40 hr/batch
Total hours of one batch	76 hr(3 days)

(b) Weight of the soil pipe charged in One batch

45 to 50 ton

(c) Amount of fuel consumption in one batch

About 6,000 litre

(2) Description

Because of the batch process, if we want to implement the accurate analysis, the data on a complete cycle, 76 hours, should be obtained with suitable interbal times. In this survay, however, due to limited time only a few data at the special time point of heating cycle was obtained. Then the rough heat balance of shuttle kiln was barely calculated with a above few data and the later taken datum.

(3) Heat Balance of Batch Operation

Differing from the continuous process, the calculation of heat balance in the batch process is slightly trouble-some. Especially, the dispersion heat loss from surface of kiln and the flue gas heat loss exhausted from kiln are estimated by graphical integration.

The only results of the calcuration for heat balance is given in Table C.5.1 as below ;

Description	Input		Output	
	kcal/batch	%	kcal/batch	%
<u>Input</u>				
Fuel	48,669,000	100		
<u>OutPut</u>				
Product Soil Pipes[1)] Heat content at 1165°C			14,729,000	30.3
Flue gas Heat Loss[2)]			14,617,000	30.0
Dispersion Heat Loss[3)]			6,341,000	13.1
Kiln Heat Content (Balance)			12,952,000	26.6
Total	48,669,000	100	48,669,000	100.0

Table C.5.1 <u>Heat Balance Sheet for Shuttle Kiln</u>

<u>Notes</u> ; 1) 50,000 x 0.26 x (1165 - 32) = 14,729,000 kcal/B. where 0.26 is specific heat of clay,

2) the value is estimated by graphical integration using the observed temperature of flue gas at respective times on heating cycle and assuming O_2 content is 10 % as constant through heating cyclr.

3) roof ; 74.7 x 15 x (100 - 32) x 34 = 2,594,000
sides ; 127.7 x 15 x (90 - 32) x 34 =3,777,000
where 74.7 and 127.7 are area in m^2 of roof and side walls respectively, 15 is the assumed heat transfer coef., 100 and 90 are average surface temperature of roof and side walls respectively, and 34 is the heating hours of the batch cycle.

The unit fuel consumption, which is the ratio of total consumption of fuel in litre to the total weight of the produt soil pipes in kg for one batch operation is ;

5,650 litre/50,000 kg = 0.113 litre/kg .

This value similar on the ceramic industries in Japan is between 0.1 to 0.13 litre/kg of ceramic product. The unit fuel consumption in this factory is reasonable comparing to that of Japanese Industries.

5.2 Dryer Operation

(1) Required Heat

(a) A mount of the water evaporated in the Dryer

Water content in the raw wet soil pipes	7 %
Water content in the dried soil pipes	2 %

50,000 x (0.07 - 0.02) = 2,500 kg/batch.

(b) Required heat

Therefore, the heat required to reduce the moisture of the raw soil pipes is calcurated as follows ;

$$Q = 50,000 \times 0.28 \times (80 - 32) - 2,500 \times 600$$
$$= 672,000 - 1,500,000$$
$$= 2,172,000 \text{ kcal/batch}$$

where 0.28 is specific heat of clay in kcal/kg. °C ,
80 is the temperature of dryer in °C, and
600 is rough latent heat of vaporization of water in kcal/kg

(2) Heat Content of Hot Flue Gas for Dryer

The heat content available in hot flue gas is estimated by graphical intgration using the temperature O_2 content of the flue gas in duct through firing cycle.

The total amount of heat energy integrated is 14,617,000 kcal/batch shown in Table C.5.1.

(3) The Efficiency of the Dryer

The efficiency of the dryer is presented as the ratio of the required heat for drying to the totalheat supplied by the hot flue gas frcm kiln. Then

Dryer efficiency = 2,172.000/14,617,000 = 0.15

= or 15 %

6 Problems in Thermal Energy Utilization and their Potencial Solutions

The factory has new shuttle kilns, one of which was diagnosed in this survay,for manufacturing of the sewerage soil pipes. As the result of this survay, the efficiency is relatively high and almost same as that of averrage Japanese industries.

6.1 Shuttle Kiln Operation

(1) Overall Efficiency of Manufacturing of Soil Pipes

The shuttle kile operation is followed to the drying process. The overall efficiency of combined processes is as follows ;

= (14,729,000 - 2,172,000)/48,669,000

= 0.347 or 34.7 %

Assuming that 10 % of the products were spoilt, the efficiency is therefore

34.7 x 0.9 = 31.2 %

(2) Air Control for proper Combustion

The mean value of O_2 content of flue gas through heating cycle was roughly estimated as about 10 %. If so in order to save the fuel, it os recommendable to operate the kiln to reduce the O_2 content of flue gas to 5 %.

The energy saved is illustrated as follows ;

O_2 Content %	Heat Loss kcal/batch	Terms
10	14,617,000	present
5	10,200,000	improvement
Saved Heat	4,414,000	7 % of fuel

This saved heat is equivalent to 4800 $/year assuming the following data ;

Annually purchased fuel	1440 kl,
Price of thermal energy	$ 0,054/1,000kcal
Density of fuel	0.84 kg/l

In this measure, the generation of the smoke from the stack should be prevent.

6.2 Dryer Operation

As shown in 5.2 the dryer operation only at 15 % efficiency which means that the flue gas from the kiln is not fully utilized by the dryer. The exess heat from flue gas could be furthermore used to dry the raw wet pipes below 2 %, provided that the quality of the dried pipes is not completely affected.

6.3 More Utilization of Flue Gas

At the present moment, the two dryer-kiln systems are operated separated. If an interconnective underground ducts between the two systems could be built to utilize the excess heat in the flue gas, we would operate more efficiently the shuttle kiln with batch processes. For example, if the flue gas from one kiln would used for preheating the raw soil pipes in the other kiln until 300°C without to damage the soil pipes on quality, the fuel consumption could be probably reduced by about 7 %.

7. Electricity

7.1 Electrical consumption characteristic

- supplier	: National Electicity Board of States of Malaya
- contractual maximum demand	: 250 kW
- average monthly consumption	: 66.5 x10^3 kWh
- factory load factor	: 0.42
- contractual power factor	: 0.85
- transformer capacity	: 750 kVA
- rated supply voltage	: 415 Volts
- electric power specific unit (EPSU)	: 73.9 kWh/ton

7.2 Schematic diagram and outline of factory

Electrical schematic diagram is as shown in figure 7.1

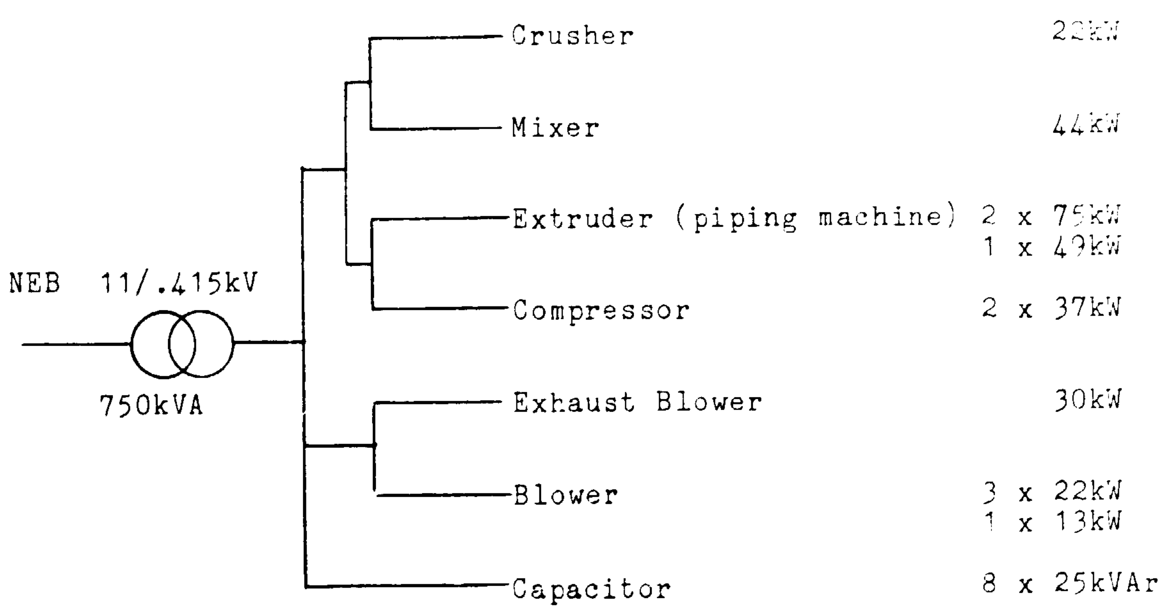


Figure 7.1 Electrical schematic diagram of GOH BAN HUAT POTTERY WORK.

The new factory which we have investigated make earthen ware sewage pipes utilizing automatic extruding machines, kilns and some electric pressers. power input is through a 750 kVA, 3 phase transfomer and maximum load demand is estimated around 250 kVA where 60% of the factory load demand as taken up the automatic extruding machines and the remainder by the kilns, dryers and other general purposes.

8. Problems in electric power utilization and their potential solutions

8.1 Source

8.1.1 Transformer

The main substation transformer is rated 750 kVA but average power requirement is about 236 kW (278 kVA assuming 0.9 p.f) It is obvious that this transformer capacity is too large for the factory. To save energy it is recommended that the substation capacity be reduced to 450 kVA. Further energy saving can also be realiezed if two transformers with capacity of 250 kVA and 200 kVA each be installed instead of one 450 kVA, where only the 200 kVA transformer is connected outside workinghours. This measure will save energy as indicated by the calculation below.

Existing Transformer;

ΔP_I = 750 (1-0.984) x 0.2 x 24 = 57.6 kWh/day

where ΔP_I : iron loss /day

0.2 : iron loss factor

24 : operating hours /day

0.984 : efficiency of 750 kVA transformer

Recommended transformers.

$$\Delta P_2 = \left\{ 200\ (1-0.977) \times 24 + 250\ (1-0.978) \times 8 \right\} 0.2$$

$$= 30.8 \text{ kWh/day.}$$

where ΔP_2 : iron loss/day

0.2 : iron loss factor

24 : operating hours of 200 kVA transformer

8 : operating hours of 250 kVA transformer

0.977 : efficiency of 200 kVA transformer

0.978 : efficiency of 250 kVA transformer

Therefore saving

= (57.6-30.8) x 0.23 x 350 =$2157/year

where 350 : number of day/year

0.23 : cost/unit of electricity

8.1.2 Voltage

From the name plates of various equipments and capacitors (power factor correction) they are rated at 415 volts but the actual supply voltage measured was 438 volts. It is therefore recommended to bring the supply voltage down to 420 volts. This measure will certainly reduce losses and over load.

8.1.3 Capacitors (power factor correction)

There are altogether eight static capacitors connected for power factor correction. Our measurements indicate that only two capacitors are in perfect working condition while the other six are defective as indicated in table 8.1 below;

No.	Mark of wire			description
	red	yellow	blue	
1	O	O	O	good
2	O	O	O	good
3	Δ	X	Δ	open circuited
4	Δ	Δ	X	open circuited
5	X	Δ	Δ	faulty connection
6	Δ	Δ	Δ	faulty connection
7	Δ	Δ	O	faulty connection
8	Δ	Δ	O	faulty connection

mark ; X : <0.3, Δ: <0.7, O: $\geqslant 0.8$, (1.0 =22.5 kVAr)

Table 8.1 Conditions of static capacitors

From the table above, it is apparent that the automatic power factor correction equipment is faulty. As a result the factory can experience over voltage and poor power factor during working hours resulting in unnecessary losses and reduce motor efficiency and the possibility of power factor penalty when the factory is operating full load. It is essential to do corrective measure to ensure that the power factor correction equipment is working in perfect order and those defective capacitors be replaced as they can also pose as fire hazards.

8.2 Electrical loads

8.2.1 Extruders

The three extruders with total installed capacity of 207 kW have cyclic load demand where on the average 25 % the machine operating time, the motors are working on peak load. The load and no load characteristic of the motors are shown in table 8.2 below.

No	Rating (kW)	Actual load (kW)	
		load	no load
1	110	110	6.3
2	100	115	7.0

Table 8.2 <u>Actual load of Extruders</u>

Using the 110 kW machine as an example the optimum rating of the motor should be 55 kW as shown by the calculation below.

$$P = \sqrt{\frac{0.25 \times 110^2 = 0.75 \times 6.3^2}{0.25 = 0.75}} = 55 \text{ kW}$$

With a safety factor of 2.0 for this nature of work the motor rating is suitably designed.

8.2.2 <u>Compressed air system</u>

It is necessary to examine the whole compressed air system in the factory because the pressure as delivered by the compressor is around 7.9 kg/cm^2 (110psi) and this pressure appears too high for the factory application. It is possible that the various equipments in the factory could very well perform at very much lower pressure than the existing value. Therefore it is recommended that the factory carry out pressure reduction exercise i.e. the machine performance. It is worth noting that for every kg/cm^2 reduction in pressure a saving of 3% of the total power consumed by the compressor.
Since the delivered air pressure is high and extensive piping, it is recommended also that the factory consider a formal program for periodic leakage checking.

9 Summary

9.1 Thermal Part

Because shuttle kiln operation on this factory is batch types, for the correctly survay it is necessary to get the proper data with time passage through full period in kiln performance. According to the limitation of the survay times the results and potentioal solution is always not expected on correctness.

(1) 1st. Phase Measures (No or little investment)

	Annually fuel saving	
	%	$
(a) O_2 control	7	4,800

(2) 2nd. Phase Measures (some investment)

The suttle kilns are comparatively well insulated and the heat balance in table C.5.1 shows that it is comparable to recomended values in Japan. Espetially, no minor change would be significant on the existing design.

(3) 3rd. Phase Measures (large-scale process change)

(a) Combined performance with two shullle kiln-dryer systems
This would require the interconnected operation of the two systems. An interconnected underground ducts between the systems should be constructed.

Provided that the quality of products of soil pipes are not affected, the fuel savings which could be obtained by this measures would be presumably about 7% of the total fuel consumption.

9.2 Electrical parts

A major electrical recmmendation for this factory was indicated in section 8.1.2 where a change in the main intake transformer from one of 750 kVA unit to two of 200 kVA and 250 kVA transformers. This will allow the 250 kVA unit to be switched off outside working hours, thus giving a saving of $2157 /year.

In section 8.1.3, we storongly recommended that efforts should be taken to replace and also periodically maintain the automatic power factor correction equipment (capacitors).

SOUTH EAST ASIA FIREBRICKS INDUSTRIES SDN. BHD.

1. Outline of the Factory

Address: 8 3/4 Miles, Jalan Ipoh, Kuala Lumpur

Capital: 4,000,000 Malaysian dollars

Type of industry: Ceramic

Major products: Refractories, heat insulating bricks, fire clay bricks, high alumina bricks

Annual production: 18,000 t

No. of employees: 150

Annual energy consumption:

- Electric power, 1,140,000 kWh
- Fuel, diesel oil, 2,720 kℓ

Interviewees: Mr. Tan Boon Chin, Refractories Engineer
Mrs. Yap Szu Lee, Chemist
Mr. Here Heng Tuan, Cost & Management Accountant

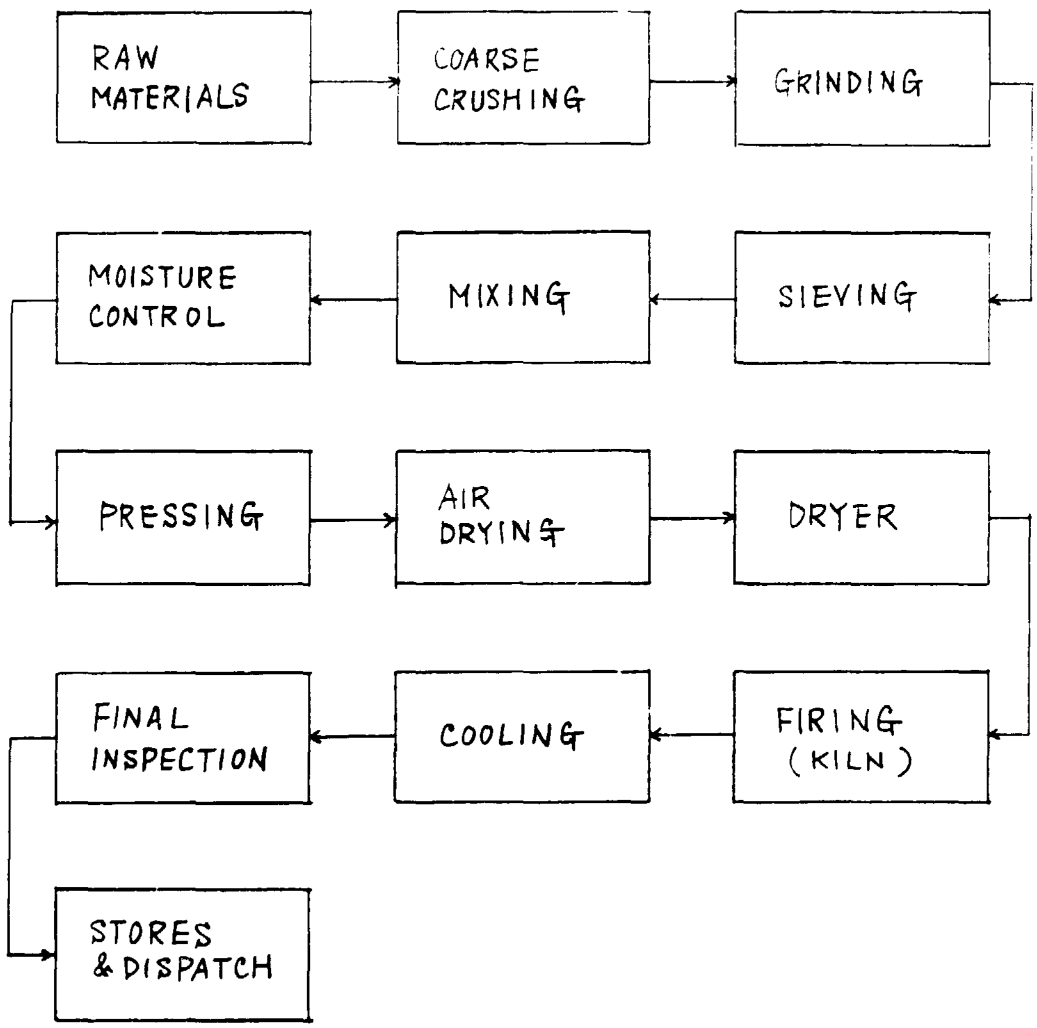
Date of diagnosis: Mar. 28 - 29, 1983

Diagnosers: Mr. M Eguchi, Mr. R. Takahashi, and Mr. T. Sugimoto

Counterparts: Dr. Mohd Ariff Araff, Dr. Ong Peng Su, Dr. Radu, Mr. Ahmd Faizul, and Mr. Arizan Ab Manan

- The factory was constructed in 1972 in the suburbs north-northwest of Kuala Lumpur. It is equipped with 2 units of down draft kilns and 3 units of tunnel kilns.
- There are two companies producing refractories in Malaysia. Each of the two companies shares 50% of the Malaysian market.

2. <u>Manufacturing Process</u>



3. Major Equipment

3.1 Major Equipment

<table>
<tr><th>Name</th><th>No. of Units Installed</th><th>Type, etc.</th></tr>
<tr><td>Tunnel kiln</td><td>3</td><td>Continuous type
<table>
<tr><th></th><th>No. 1</th><th>No. 2</th><th>No. 3</th></tr>
<tr><td>Built</td><td>1973</td><td>1979</td><td>1982</td></tr>
<tr><td>Products</td><td>Fireclay bricks</td><td>High alumina bricks</td><td>Fireclay & chammotte bricks</td></tr>
<tr><td>Output/ day</td><td>20.8 t</td><td>8.5 t</td><td>31.0 t</td></tr>
</table>
</td></tr>
<tr><td>Downdraft kiln</td><td>2</td><td>Batch type
Built: 1972
Products: Chammotto
Output: 60 t/charge</td></tr>
<tr><td>Dryer</td><td>3</td><td></td></tr>
</table>

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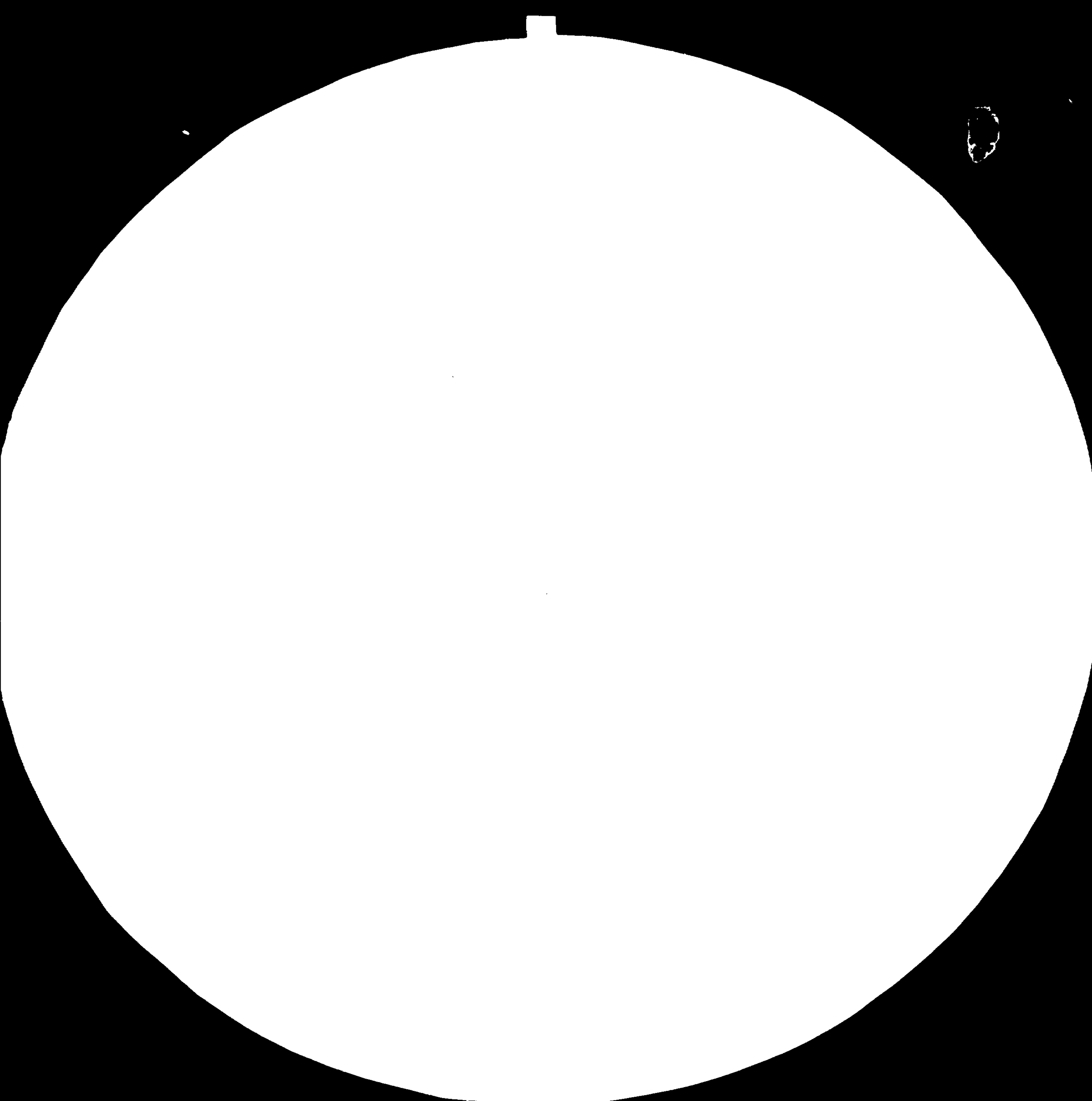
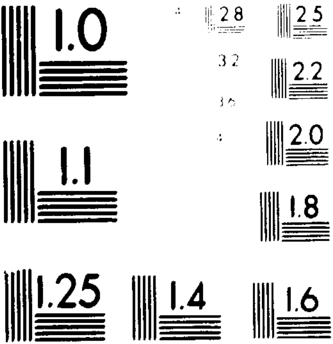
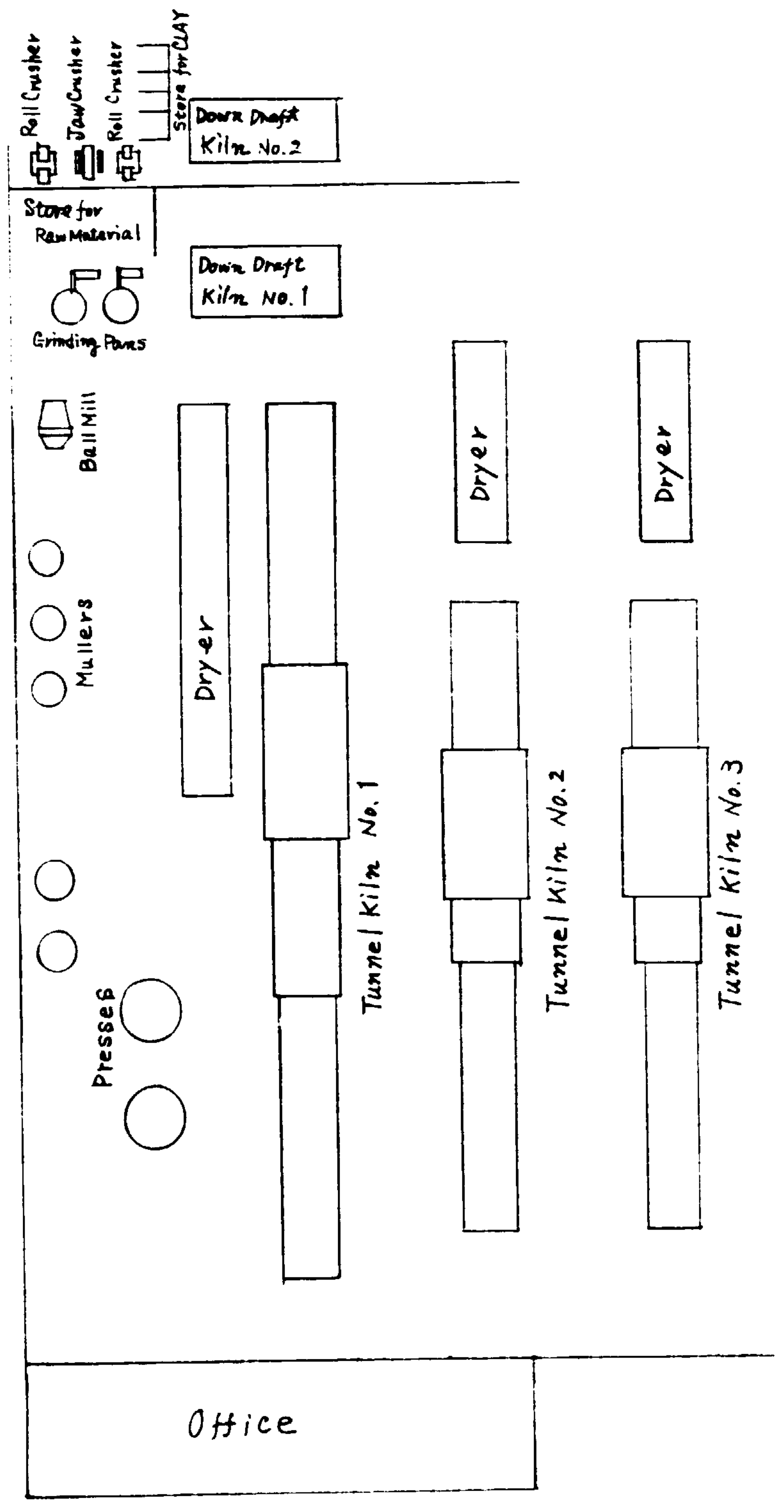




MICROCOPY RESOLUTION TEST CHART

3.2 Layout


Roll Crusher
Jaw Crusher
Roll Crusher
Store for CLAY
Down Draft Kiln No. 2
Store for Raw Material
Down Draft Kiln No. 1
Grinding Pans
Ball Mill
Mullers
Dryer
Dryer
Dryer
Tunnel Kiln No. 1
Tunnel Kiln No. 2
Tunnel Kiln No. 3
Presses
Office

4. Situation of Energy Management

- There is no organization or system to promote the energy-conservation. The company conducts no particular PR for energy-conservation to its workers.
- As for workers training, personnel higher than a supervisory level are made to attend seminars from time to time. But, there is no training program for general workers.
- The energy cost to the turnover has risen to 22.4%. And the company has adopted a plan to energy-conservation. But, there is no specific target set for the reduction in fuel and electric power costs and the date of achievement. The company considers it sufficient to save energy even slightly from the current level.
- Many companies rely on suppliers in the purchase of fuel, but the company conducts a confirmation of weight.
- The electric power consumption is monthly confirmed through the bill as to the consumption by the whole factory. Recording is made daily on the fuel consumption together with recording on other operation by each kiln. The energy consumption rate (kg/kg) is calculated, setting the criteria for operations. However, there is no production process control through the preparation of a process chart as generally done in Japan.
- Attention is paid to the maintenance and quality control including the cleaning of burners once a week, the chemical analysis of raw materials, sizing test, etc.

5 Situation of Fuel Consumption

The data of the Unit Fuel Consumption for each kiln up to the present have been evaluated by the factory as follows ;

No. 1 Kiln	1,100 kcal/ kg of product
No. 2 Kiln	1,650 kcal/ kg of product
No. 3 kiln	850 kcal/ kg of product

According to the requests of factory manager, only No. 2 Kiln which is the worst in the unit fuel consumption has been diagnosed on this survay.

5.1 No. 2 Tunnel Kiln

5.1.1 Data used in Heat Balance Calculation

(1) Factory Data

(a) Unit Fuel Consumption 1,650 kcal/kg of P.

(b) Amount of Produced Bricks per Day 8,500 kg/day

(c) Fuel Calorie Inputed per Hour

(1,650 x 8,000)/24 = 584,400 kcal/hr

(2) Measured Data

A) O_2 Content in Kiln

(a) Cooling zone	18 %
(b) Combustion zone	13 %
(c) Preheating zone	13 %
(d) Flue Gas	12 %

B) Dispersion Heat Loss using observed Heat Flux and Area

a) Cooling zone	55,700 kcal/hr
b) Combustion zone	101,700 kcal/hr
c) Preheating zone	42,400 kcal/hr
Total	199,800 kcal/hr

C) Flue Gas Heat Loss 100,850 kcal/hr

D) Hot Gas to Dryer 196,400 kcal/hr

E) Car Cooling Heat Loss 58,900 kcal/hr

F) Heat Content of Product and Car 15,400 kcal/hr

5.1.2 Heat Balance Sheet of No. 2 Kiln

The heat balance for tunnel kiln operation based on hr is shown in Table D.5.1 as follows ;

Description	Input		Output	
	kcal/hr	%	kcal/hr	%
Input				
Fuel	584,400	100.		
Output				
Hot Gas to Dryer			196,400	33.6
Car Cooling Heat Loss			58,900	10.1
Flue Gas Heat Loss			100,850	17.3
Dispersion Heat Loss			199,800	34.2
Heat content of car and Products			15,400	2.6
Balance (Uncountable)			13,050	2.2
Total	584,400	100.	584,400	100.0

Table D.5.1 Heat Balance Sheet of No. 2 Kiln

Actually, the heat carried out by the products from the kiln is only about 5,000 kcal/hr. The efficiency in common sense results in 5,000/584,400 = 0.009 or 0.9 %. This value is too small. Then normally the efficiency on the case of the tunnel kiln operation is substituted by the ratio of the maximum required heat of product to the total inputed fuel heat. The new defined efficiency is ;

$$354 \times 0.28 \times (1250 - 30) = 120{,}900 \text{ kcal/hr}$$
(maximum required heat)

$$120{,}900/584{,}400 = 0.207 \quad \text{or } 20.7\%$$

Where 354 is weight of product per hr in kg,
1250 is maximum required temperature in ^{o}C and
0.28 is the specific heat of the brick.

5.2 <u>No. 1 and No. 3 Kiln Operations</u>

No measurement has been made on No. 1 and No. 3 Tunnel kiln in this survay. Based on the data provided by the factory, the unit fuel consumption for the two kilns are as follows ;

No. 1 ; 850 kcal/kg of product or
83 kg of fuel/tonne product and

No. 3 ; 1100 kcal/kg of product or
108 kg of fuel/tonne product

These values are comparable to that of similar kiln for the ceramic product in Japan which have the values of between 64 to 170 kg of fuel/tonne product on the unit fuel consumption.

6 Problems in Thermal Energy Utilization and their Potential Solutions

Refering to Table D.5.1,about 65 % of the fuel energy inputed in No. 2 Kiln is thrown out to ambient,that is, surface heat loss, car cooling heat loss , flue gas heat loss, et al. The balance which is about 35 % is used only in the dryer. In Japan this value is almost comparable.

6.1 O_2 Content in Flue Gas

The O_2 content in the flue gas of the tunnel kiln is excessive compared to the recommended valur of 5 %, as being applied in some similar Japanese factories.
To reduce the O_2 content in the flue gas to as low level as possible, it is recommendable that O_2 gas analizer should be installed in exhausting duct and inlet air flow rate for combustion should be controlled not so as to produce the soot or smoke from the stack.

If O_2 content could be reduced by 1 %, the fuel savig would be in the order of 1.0 to 2.0 % of the fuel consumption depending on former O_2 content.

6.2 Extensive insulation of the roof side wall surfaces of the tunnel kilns

The heat balance sheet of Table D.5.1 shows that the heat losses through the surface of kiln account to about 30 to 40 % of the total fuel consumption. Such high heat losses would be effectively recovered by appling a suitable insulating materials onthe surface of the kiln.

Assuming the constancy of the heat transfer coefficient, the decrease of 30% of temperature difference between the surface of kiln and ambient would result in the saving of 10% of total fuel consumption.
Actually, because of the limited spaces of the inside of kiln, it is recommendable to spray the ceramic fibre on the surface of roof and/or to place the ceramic board on the surface of side walls not so as to exceed the allowable temperature of the framed steel.

7 Electricity

7.1 Electricity consumption chracteristic

- supplier	: National Electricity Board of the States of Malaya.
- contractual maximum demand	: 320 kW
- average monthly consumption	: 95 x 10^3 kWh
- factory load factor	: 0.20
- contructual power factor	: 0.85
- transformer capacity	: 1000 kVA
- rated supply voltage	: 415 volts
- electric power specific unit (EPSU)	: 63.3 kWh/ton

7.2 Schematic diagram and outline of factory

Electrical schematic diagram is as shown in figure 7.1.

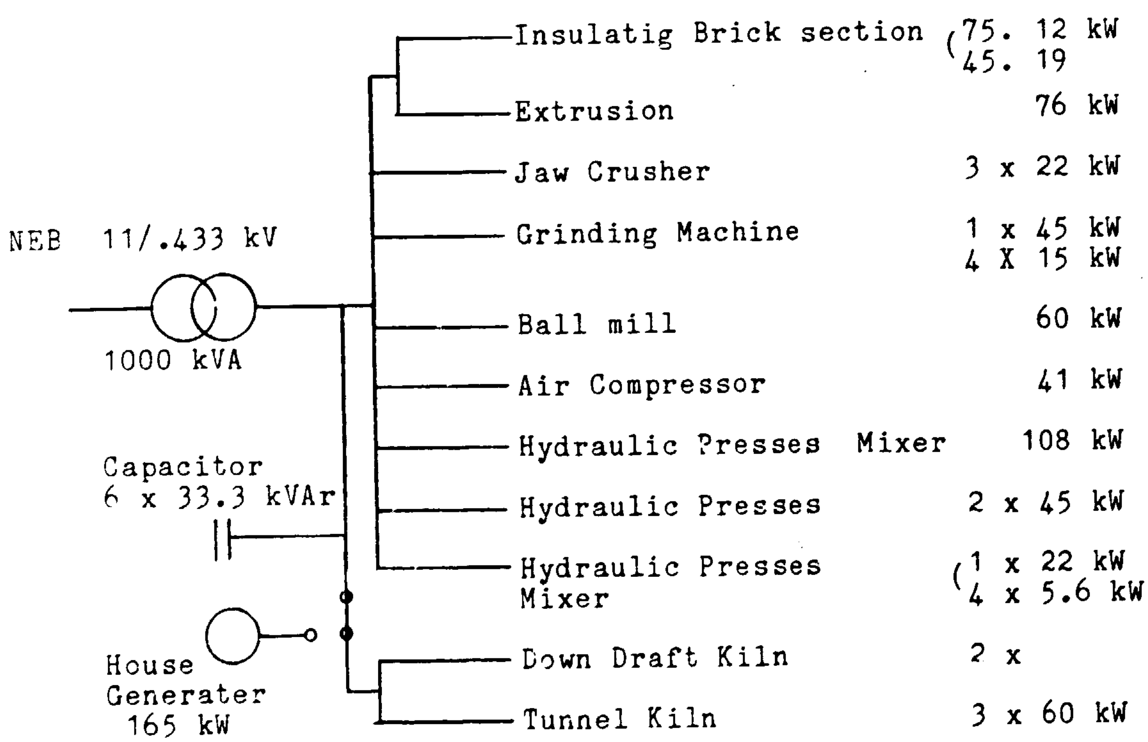


Figure 7.1 Electrical schematic diagram of SOUTH EAST ASIA FIRE BRICKS INDUSTRIES SDN. BHD.

Most of the electrical load in the factory is in the material and handling and processing section where large motors for crushing and pressing of raw material are used. The factory has three tunnel kiln and two down draft (batch system) kilns. The source of electricity supply is through a 1000 kVA, 3 phase transformer.

Generally the load is less than 200 kW during the day peak demand. The machines in the material handling section are operating for 9 hours/day with a diversity factor of 0.75 and the remainder of the equipments connected to the kilns and dryers are operating for 24 hours/day.

8. Problems in electric power utilization and their potential solutions

8.1 Source

8.1.1 Transformer

The transformer is rated at 1000 kVA with a maximum load of 333 kVA of which 50% is required continuously. As shown in table 8.1 giving the details of the factory installed capacity and the power consumed by each section, it is obvious that the existing transformer is overdesigned.

Job Description	Installed capacity (kW)	Power consumes (kW)	Recommended trance-Formers capacity (kVA)
Raw material & processing	810	275	500
Kiln	200	70	200
Total	1010	345	700

Table 8.1 Details of factory installed capacity and power consumed

Therefore it is recommended that the existing transformer be replaced by two transformers of rating 200 kVA and 500 kVA each. The transformer should be switched off during non-working hours to reduce power loss. As shown in the culculation below a saving of $1515/year could be realized.

Existing Transformer

ΔP_1 = 1000 (1-0.985) x 24 x 0.2 =72 kWh/day

where ΔP_1 :iron loss/day

0.2 :iron loss factor

24 :working hours of transfomer/day

0.985 : efficiency of 1000 kVA transfomer

Recommended Transformers

$\Delta P_2 = \{200 (1-0.977) \times 24 + 500 (1-0.983) \times 15\} 0.2$

=47.6 kWh/day

where ΔP_2 : iron loss /day of new system

0.2 : iron loss factor

24 : working hours of 200 kVA transformer

15 : working hours of 500 kVA transformer

0.977 : efficiency of 200 kVA transformer

o.983 : efficiency of 500 kVA transformer

Therefore saving/year

= (72-47.6) x 270 x 0.23 =$ 1515/year

where 270 : working days/year

0.23 : cost of electricity per kWh

8.1.2 Voltage

The name plates of the various equipments indicate that the equipments are rated at a voltage of about 400 volts. However the actual supply voltage as measured was 440 volts. It is recommended that the supply voltage be stepped down to a value of 420 volts.

8.1.3 Power factor

Generally the power factor in the factory is good. This is because the factory has an automatic power factor correction equipment. However well a house is kept, it should be maintained all the time to achive the good power factor.

8.2 Electrical loads

8.2.1 Extruder

The factory has one extruding machine of rated capacity 76 kW. However our measurement indicates that the useful power on full load is only 24 kW. this owes a load factor of the extruder to be 0.32. In our opinion the motor in the extruding machine is glossly overdesigned. Therefore it is recommended that the existing motor to be replaced by a smaller one of capacity around 50 kW.

8.2.2 Hydraulic presses

There are a few hydraulic presses of various (from 18 kW to 90 kW) in the factory, measurements were made for a duration of 10 minutes on one 90 kW press and one 18 kW press. The results of which are as tabulated in table 8.2 from the measurement of the 90 kW hydraulic press, it was found that the motor is overdesigned. Therefore in our opinion it is recommended that the existing

90 kW motor to be replaced by one 75 kW motor so that losses could be reduced.

Motor Capacity (kW)	Load (kgs)	Actual power consumed (kW)			Pressure (kg/cm)	
		Min.	Max.	Average	Min.	Max.
90	200 x 10	25	81	40	7	300
18	100 x 10	1.4	6.7	4.1	3.5	70

Table 8.2 Loading of hydraulic presses

8.2.3 Lightings

Generally the whole factory lightings are made of fluorescent lamps and mercury vaper lamps. It was found that some of the mercury vaper lamps in the kiln section are not in operating order and the whole factory lighting fitting have not been regularly cleaned. From our measurements luminosity during the day time is just sufficient. However in our opinion luminosity at night is insufficient. Therefore it is recommended that the factory lightings to be changed to metal halide lamps or marcury fluorescent lamps (of rating 400 watts cach) for energy saving and easy maintenance.

9 Summary

9.1 Thermal Part

No.2 tunnel kiln has a smaller dimension and capacity and a higher unit fuel consumption compared to No 1 and No. 3 tunnel kilns. The problems in this factory are to improve the unit fuel consumption to the level of another kilns.

	% of fuel saving based on only No.2
(1) 1st. Phase Measures (no or litle investment)	
(a) O_2 Content Control	about 10%
(2) 2nd. Phase Measures (some investment)	
(a) Extensive insulation on surface of No. 2 tunnel kiln	about 10%
(b) Expediting the installation of the predrying plant for the moistured raw clay using the flue gas from No. 1 and No. 3.	-

9.2 Electrical parts

On the electrical side the avenues for energy saving is rather limited except for the transformer rating as shown in section 8.1.1.

GENERAL CERAMIC MANUFACTURES SDN. BHD.

1. Outline of the Factory

Address: 6 Jalan Bersatu, Petaling Jaya

Capital: 10,000,000 Malaysian Dollars

Type of industry: Ceramic

Major products: Ceramic wall tiles

Annual output: 64,558,000 pieces (about 6,456 t)

No. of employees: 265

Annual energy consumption:

- Electric power, 1,862,426 kWh
- Fuel, diesel oil, 3,126 kℓ

Interviewees: Mr. Anthony Eccles, Factory Manager

Date of diagnosis: Mar. 31, Apr. 1, 1983

Diagnosers: Mr. M. Eguchi, Mr. T. Takahashi, and Mr. T. Sugimoto

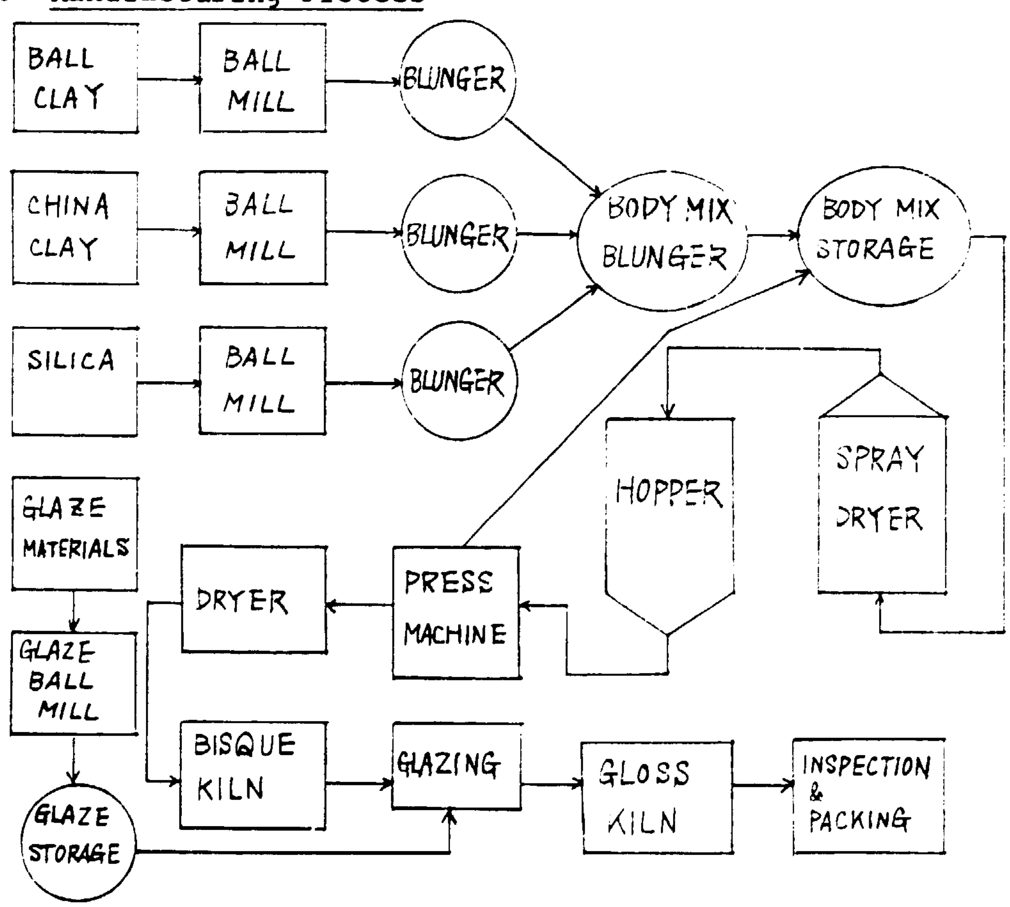
Counterparts: Dr. Mohd Ariff Araff, Dr. Ong Peng Su, Mr. Ahmed Faizul, and Mr. Alizal Ab. Manan

. Petaling Jaya, where the factory is located, is a rapidly grown modern satellite city on the southwest of Kuala Lumpur. Many of the major factories are forming an industrial complex in the area.

. The factory was constructed in 1970. It is equipped with 2 units of large spray driers, 8 units of forming machines, and 3 units of tunnel kilns, and is producing wall tiles.

- There are two companies producing tiles in Malaysia, one of which is a joint venture with a U.K. firm, and the other is this company. The company shares about 25% of the market, and is planning an expansion of the production facilities in the future.
- The company has a very strong concern for energy-conservation. Energy-conservation is studied by the cost-saving committee, but is not very active in practice, yet.
- The company once received an energy-conservation consultation of Shell Company.

2. <u>Manufacturing Process</u>

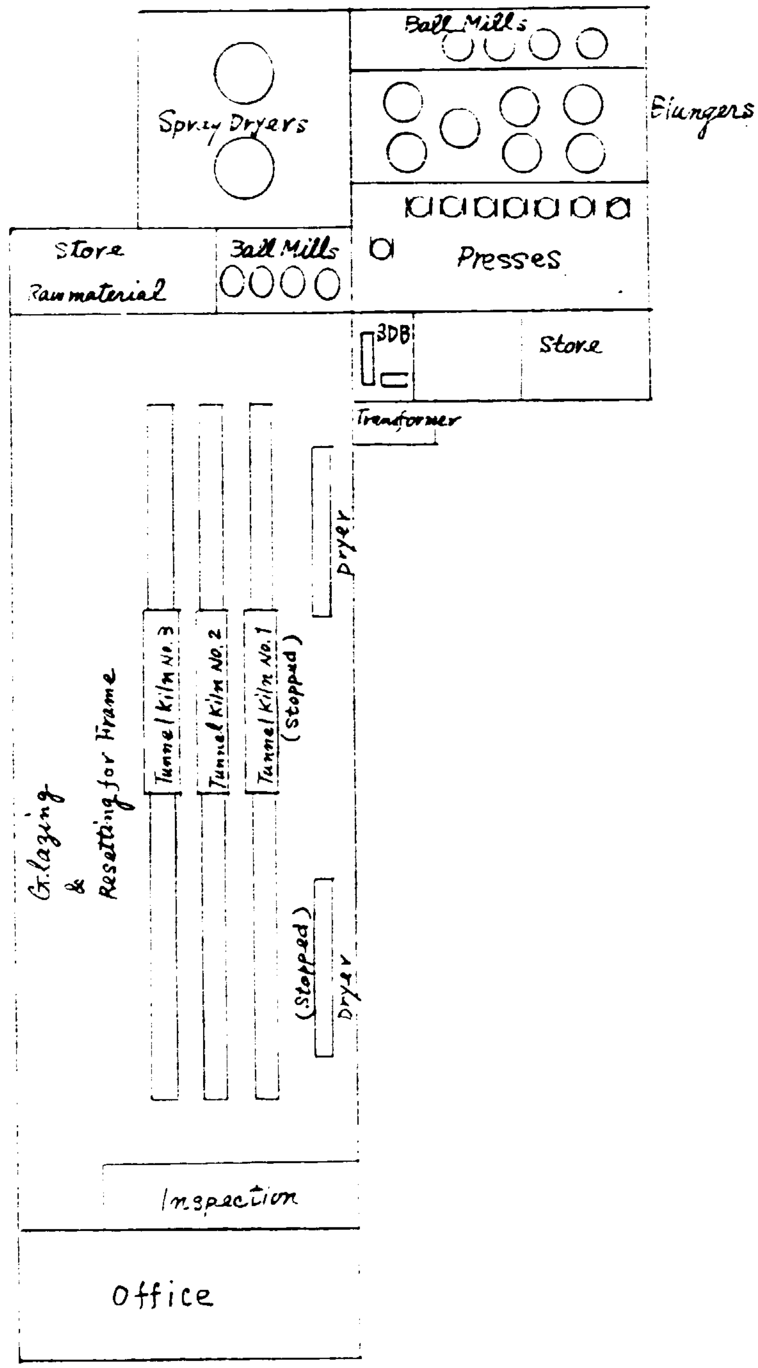


3. Major Equipment

3.1 Major Equipment

Name	No. of Units Installed	Type, etc.
Tunnel kiln	3	Kind of Energy used: Diesel oil No. 1 Kiln: Stopped No. 2 Kiln: For bisque tiles No. 3 Kiln: For glossed tiles
Dryer	2	Kind of Energy used: Waste gas of tunnel kiln No. 1 Dryer: Stopped
Spray dryer	2	Kind of Energy used: Diesel oil Fuel consumption: 181.44 kg/8 hrs. Production capacity: 3,500 kg/h

3.2 Layout


Ball Mills
Spray Dryers
Plungers
Presses
Store
Raw material
Ball Mills
3DB
Store
Transformer
Dryer
Tunnel Kiln No.3
Tunnel Kiln No.2
Tunnel Kiln No.1
(Stopped)
Glazing
&
Resetting for Frame
(Stopped)
Dryer
Inspection
Office

4. Situation of Energy Management

- The production cost saving committee is held weekly. Energy-conservation is one of the agenda of the committee meeting.
- The company once received the guidance on energy-conservation from an expert organization.
- The energy-saving investment was so far made on the heat insulation. The company desires to invest for energy-conservation, provided the pay-back period is less than two years.
- At fuel receiving, the officer-in-charge checks on quantities by the flow meter set on the receiving tank.
- Fuel consumption is daily measured every production equipment of kiln and spray driers, and is compiled monthly as well as yearly, and the energy consumption rate is calculated as well as cost accounting is done. The results are kept as data for examination. However, there is no examination through a control chart as generally done in Japan.
- Technical staff are made to attend seminars on energy. But, there is no training program for general workers, nor there is a campaign made by the factory manager toward workers.

5 Situation of Fuel Consumption

In last year, 1982, 687,723 Imperial Gallons of diesel was purchased by this factory. The tunnel kilns which operate for 24 hours per day consume 80 % of the fuel, the remaining 20 % is consumed by the spray dryer which operate for 8 hours per day. Operating data presented by the factory show that the fuel consumption rate for the tunnel kilns is 1600 I.G./day and for one spray dryer is 400 I.G./day.

The data of the fuel consumption rate would be used for analysis in this report.

5.1 No. 2 Tunnel Kiln for Bisque Production

The facilities of the factory comprise of 3 tunnel kilns, 2 tunnel dryers and 2 spray dryers. During the study period, one tunnel kiln one tunnel dryer and the smaller size spray dryer have not been operated. 1,600 I.G./day as the fuel consumption rate is the combined value for one bisque kiln and one glost kiln.

The waste heat from the cooling zone of the bisque kiln has been utilized for the heat of the tunnel dryer. Since actually the individual consumption of fuel oil by the bisque and glost kilns could not separately measured, in convenient the fuel on respective kiln is consumed according to the proportion of the numbers of burner attached to each kilns. This is a big asumption. If later the individual fuel consumption could be clear by the suitable means, all the analysis should be checked.

5.1.1 Operating and Measured Data

(1) Fuel Specification

(a) Type of Fuel	Diesel
(b) Gross Calorific Value	19,300 Btu/lb
	10,720 kcal/kg
(c) Specific Gravity	0.84
(d) Fuel Consumption Rate	700 I.G./day

$$1600 \times 14/(14+18) = 700$$

where 1600 is the combined fuel consumption, and 14 and 18 are the numbers of burner in bisque and glost kiln, respectively.

(2) Operating Condition

A) Flue gas condition

(a) O_2 content in flue gas at stack	15.6 %
(b) O_2 content at preheating zone	7.4 %
(c) Temp. of flue gas at stack	183 °C

B) Car track time — 80 min/car

C) Temperature of tiles

(a) Raw dried tiles at input	125 °C
(b) Finished tiles at output	130 °C

D) Weight of the pile of tiles and car

(a) The pile of tiles on one car	1,300 kg
(b) The refractory brick on one car	2,221 kg
(c) Steel structure of one car	1,820 kg

E) Dryer condition

(a) moisture content of raw tiles	7 %
(b) moisture content of dried tiles	0 %

5.1.2 Heat Balance for Bisque Manufacturing Process

The heat balance sheet for combined system of the bisque kiln and raw clay tile dryer is shown in table E.5.1 as follows ;

Description	Input		Output	
	kcal/hr	%	kcal/hr	%
Input				
Fuel	1,110,212	100.0		
Output				
Flue gas from kiln			197,549	17.8
Exhaust from dryer			12,867	1.2
Car cooling air			109,264	9.8
Heat of evaporation in dryer			79,750	7.2
Dispersion heat loss bisque kiln			566,031	51.0
Dryer			54,600	4.9
Heat content of outputed car			60,398	5.4
Heat content of product at output			26,754	2.4
Other (Balance)			3,000	0.3
Total	1,110,212	100.0	1,110,212	100.0

Table E.5.1 Heat Balance Sheet of Bisque Kiln

5.2 Spray Dryer

The factory data showed that 400 I.G. of fuel was consumed for one day or 8 hours by the spray dryer. This value was found to be higher conparing to the design capacity descrived as 1,500,000 kcal/hr or 315 I.G./8 hrs in instruction book. On the analysis in this reports, the lower value, 1,500,00 kcal/hr, was used.

5.2.1 Operating and Measured Data

(1) Raw Material

(a) Slurry feed rate		4,860 kg/hr
(b) Slurry density		1.66 kg/litre
(c) amout of water in slurry		1,640 kg/hr

(2) Drying Condition

(a) Output rate of dried granular clay		3,500 kg/hr
(b) Composition of granule		
Solid (clay)	; 92 %	3,220 kg/hr
Water	; 8 %	270 kg/hr
c) Water to be evaporate from slurry		1,370 kg/hr

(3) Temperature of Combustion hot Air entering into Spray chamber

Measured	405 °C
Design	400 to 600 °C

(4) Discharged Temperature of Granular Product ;

47 °C

(5) Flue Gas Condition

a) O_2 content	17.8 %
(b) Temperature	106 °C

5.2.2 Heat Balance on Spray Dryer Operation

The heat balance sheet on the spray dryer operation is presented using above data in Table E.5.2 as belows ;

Description	Input		Output	
	kcal/hr	%	kcal/hr	%
Input				
Fuel	1,500,000	100.0		
Output				
Flue Gas Heat Loss			319,000	21.3
Water Evaporated from Slurry			794,600	53.0
Heat Content of dried Product			18,700	1.2
Dispersion Heat Loss			135,800	9.1
Balance (uncountable)			231,900	15.4
Total	1,500,000	100.0	1,500,000	100.0

Table E.5.2 Heat Balance Sheet on Spray Dryer Operation

6 Problems in Thermal Energy Utilization and their Potential Solutions

6.1 No. 2 Bisque Tunnel Kiln

The heat balance sheet of the No. 2 bisque kiln as in Table E.5.1 is suggesting that about 50 % of the fuel consumed is dispersed through the large surface of kiln. Then Extensive insulation on the surface of kiln to reduce the dispersion heat loss would be the most effective measures. Secondary measures to be worth considering would be the recovery of heat from flue gas in kiln which acounts about 20 % of fuel consumption.

6.1.1 Extensive Insulation on the outside surface of walls and roofs on tunnel kiln

According with the observed data of almost all the kiln surface, most of the temperatures have been ranged between 50 °C to 100 °C except the plates around the burners which have the temperature of about 150 °C to 200 °C.

Based on similar tunnel kilns in Japan, it would be desirable to reduce the surface temperatures beyond the standard criteria to as low as pos ible. According to the experience in Japan, the surface temperature of the kiln surface could be decreased with additional insulation, rock or ceramic wool, on kiln surface by 20 % to 30 % easly. If similar measures were taken on this kiln, the fuel consumption could be reduced by roughly 8 % to 10 %. Assuming that the fuel consumption for all kilns is roughly 2400 kl/year and fuel price is approximately $ 0.5/litre for convenience of easy account, due to this measures about $ 120,000 would be saved annually.

6.1.2 O_2 Content Control in Flue Gas

The No. 2 bisque tunnel kiln has been operated at slightly high level of O_2 content, 7.4 %. Even up to now, Japanese factories operating the tunnel kilns are endeavouring to reduce the O_2 content of the atmosphere in preheating zone to 5 % or air ratio = 1.3 . If it were possible to reduce it to 5 %, the saving of 1 % of fuel consumption for kilns would be achieved. This O_2 content reduction can be carried out by cotrolling the intake of secondary combustion air to burners. This savings result in about $ 12,000.

6.1.3 Efficiency of the Tunnel Kiln Operation

The efficiency of the tunnel kiln operation is often defined as follows ;

$$\frac{\text{Required heat to heat up the product to its maximum temperature}}{\text{Input of total Heat}} \times 100$$

Based on the above equation, the efficiency of No. 2 bisque kiln is about 25 % which is similar to average values of the efficiency of similar tunnel kilns in Japan.

6.2 Spray Dryer

As shown in the heat balance sheet in Table E.5.2, the efficiency on evaporation of water from slurry accounts to 51 % of the total heat input. Then this spray dryer relatively has being operated with good conditions.

6.2.1 Hot Air Generating Furnace

According to the instruction book, the designed values for hot air temperature entering into the drying chamber are to range between 400 to 600 °C. Otherwise the observed value of the air temperature at nearest point in duct pipe to the spray chamber was 405 °C and the calculated combustion air temperature using the observed data on the supplied fuel rate and O_2 content in the exhausted flue gas was 401 °C. The difference, about 200 °C, between the desinged and observed air temperatre will suggest that there are possibilities to save the fuel according to reduce the intaken air rate and then to increase the combustion air temperature to allowable level, about 600 °C, provided the quality of dried granular clay product is no influence.

With this measure the flue gas volume could be reduced by 27 %. This would save the fuel and electric consumption owing to reducing the flue gas heat loss and the loading capacity of flue gas discharge fan.

6.2.2 Possibility of Full Utilization of Flue Gas from Tunnel kiln

In present the spray dryer is using the combustion air from ambient in exgess of 5 to 6 times of the theoretical air requirement for complete combustion. There are the possibilities that the combustion air of the spray dryer might be taken from the tunnel kiln flue gas which has O_2 content of 15.6 %, 183 °C and volume flow rate of

4000 m^3/hr in order to save the heat.

It should be recognized that presently the heat content of flue gas from tunnel kiln stacks is only wasted to the ambient. Although a carful and skilled plan is required in conducting this improvement that long and huge ducts should be installed from the tunnel kiln to the combustion chamber of spray dryer. According with the this measures the saving of fuel might be 13.9 kg/hr which is equivalent of about $ 20,000/year, checking the sulphur content in flue gas as follows.

6.2.3 Problems on Sulphur Content and Dew Point of Exhausted Flue gas for Reutilization

The sulphur content in the flue gas is derived from the combustion of fuel with 1 %wt. sulphur which is burned in the spray dryer and the tunnel kiln. Therfore in order to prevent the steel constructing the dryer from the corrosion, the sulphur content and the dew point of the flue gas should be examined before the flue gas is reused.

(1) Sulphur Content

(a) The total fuel consumed per hour by the bisque tunnel kiln and the spray dryer is ;

111.4 + 151.2 = 263 kg of fuel/hr

(b) Assuming sulphur is 1 %wt. of fuel composition, the weight of sulphur burned during combustionin both furnaces is ; 2.63 kg of sulphur/hr.

(c) Volume of flue gas with the moisture produced by spray dryer is ; about 13,000 m^3/hr.

(d) SO_2 content of the flue gas in the combined systems is

(2.63/32) x 22.4/13,000 = 0.00014 or 0.014% vol.

where 32 is molecular weightof sulphur and 22.4 is the volume of 1 kg mol. at standard condition in m^3

(2) Dew Point

(a) Water vapour from H in fuel 411.7 m^3/hr

(b) Water vapour from slurry 1,705.0 m^3/hr

(c) Total volume of flue gas about 13,000 m^3/hr

(d) Partial vapour pressure and dew point

(411.7 + 1706.0)/13,000 = 0.16 atm.

refering the coventional steam table, the dew point corresponding to 0.16 atm of partial water vapour pressure is 55 ^{o}C.

7 Electricity

7.1 Electrical consumption characteristics

- supplier : National Electricity Board of the States of Malaya.
- contractual maximum demand : 340 kW
- average monthly consumption : 164×10^3 kWh
- factory load factor : 0.49
- contractual power factor : 0.85
- rated supply voltage : 415 volts
- electric power specific unit (EPSU) : 30.2 kWh/1000 pcs.
- transfomer capacity : 750 kVA

7.2 Schematic diagram and outline of factory

Electrical schematic diagram is as shown in Figure 7.1.

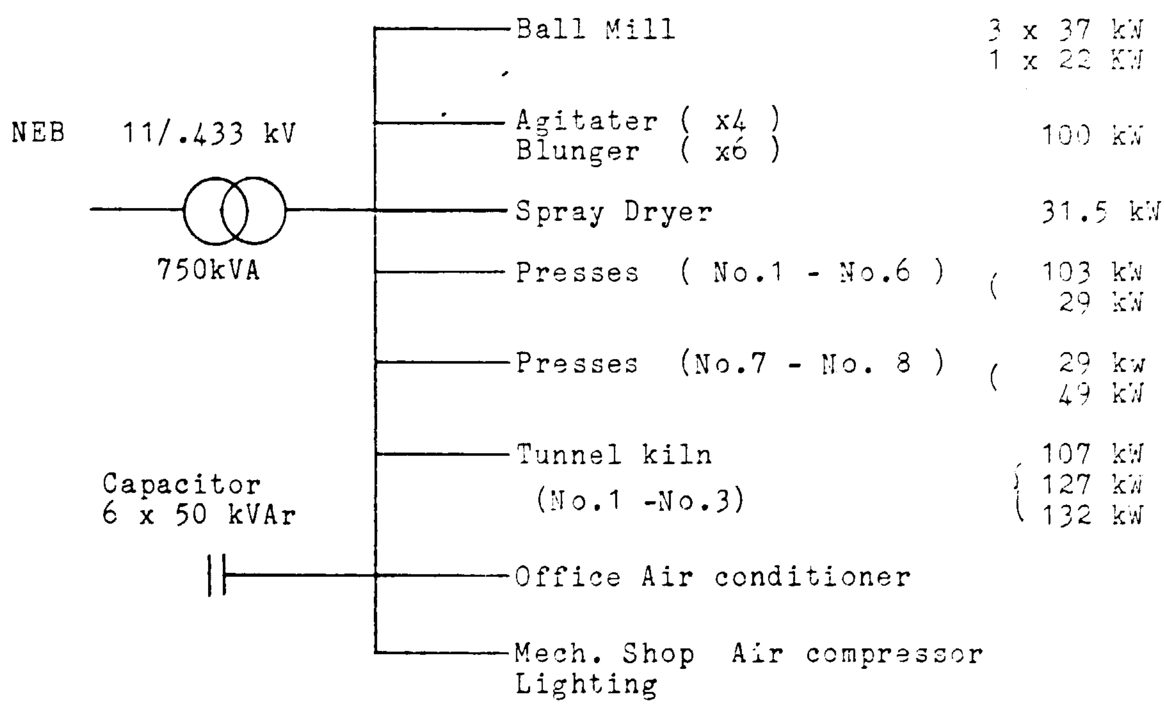


Figure 7.1 Electrical schematic diagram of GENERAL CERAMICS BHD.

This factory produces various types of glazed wall tiles. Major equipments are three large tunnel kilns, two spray dryers, four ball mills and eight hydraulically controlled presses with fly wheels. The electrical source is via 750 kVA, 3 phase transformer. The major electrical loads are four ball mill motors (37 kW each), eight hydraulic press motor (22 kW each) and thirty seven smaller motors distributed all over the factory of rated capacity of 7.5 kW each. The average factory power consumption during working hours is 340 kW (386kVA assuming p.f of 0.9). This indicates that the main transformer is lightly loaded.

8. Probrems in electric power utilization and their potential solutions

8.1 Source

8.1.1 Transformer

As stated earlier the average transformer load factor is avout 0.5. This is considered low for this purpose and it is recommended that the transformer be replaced by two transformers rated at 200 kVA and 300 kVA each making a total capacity of 500 kVA. the 300 kVA transformer can be switched off during non-working hours to reduce transformer losses. this measure will provide a yearly saving in electrical energy as follows;

Existing transformer

ΔP_1 = 750 (1-0.984) x 24 x 0.2 =57.6 kWh/year

where ΔP_1 : iron loss of 750 kVA transformer

24 : working hours/day

0.2 : iron loss factor

0.984: efficiency of 750 kVA transformer

Recommended transformers

$$\Delta P_2 = \left\{(300\ (1-0.981)\ x\ 8) + (200\ (1-0.978)\ x\ 24)\right\} 0.2$$

$$=30 \text{ kWh/day}$$

where ΔP_2 : new iron losses of transformer

24 : working hours of 200 kVA transformer

8 : working hours of 300 kVA transformer

0.2 : iron loss factor

0.981: efficiency of 300 kVA transformer

0.978: efficiency of 200 kVA transformer

Therefore the annual saving is;

(57.6-30.2) x 355 x 0.23 = $2237/year

where 355 : workig days/year

0.23 : cost of electricity per kWh

8.1.2 Voltage

The name plates of the various equipments show that they are rated at 420 volts. However the actual supply voltage as measured is 438 volts. It is recommended that, since this factory has many motors the supply voltage be lowered to the 420 volts. This recommendation will increase the efficiency of the motors and provide considerable energy saving as shown by the following culculation.

Since the total installed motors is about 870 kW and using the diversity factor of the motors as 0.7 and load factor of 0.55 during working hours, the average output of each motor can be shown to be 4.4 kW.

Therefore considering iron loss only (motor lightly loaded) the saving in energy, thus;

$$4.4 \times \left\{(1-0.825) \times 0.3\right\} \times \left\{\left(\frac{438}{420}\right)^2 - 1\right\} \times 200 \times 0.7$$

$= 2.85$ kW

where 0.825 : efficiency of motor
0.3 : iron loss factor
200 : number of motors
0.7 : diversity factor
438 : existing voltage
420 : new recommended voltage

saving/ year is given by

$2.85 \times 9 \times 355 \times 0.23 = \$2094/\text{year}$

where 9 : working hours/day
355 : working days/year
0.23 cost of electricity per kWh

3.1.3 Power factor correction equipment

This factory has automatic power factor correcting equipment which maintained good power factor 0.88 as indicated by our measurements. However the capacitors about 600 watts further to this, it was found that the capacitors are very hot and that we would like to make the following recommendations:

(1) The capacitors housing should be modified to allow good ventilation.

(2) The two tire arrangement of capacitors to be modified to single tire.

(3) To adjust the automatic control such as the capacitors

to be switched off at a power factor of 0.85 and above. This procedure will save energy as follow;

0.6 x 4 x 365 x 0.23 = $4836/year

where 0.6 : kW consumed by each capacitor
4 : number of capacitors
24 : working hours/day
365 : working days/year
0.23 : cost of electricity per kWh

8.2 Electrical loads

8.2.1 Motors

The factory has eight hydraulic presses and each of these presses has a possible maximum load of 40 kW. The maximum load is only required for a very short period, giving the motor operating chracteristic as indicated in table 8.1.

Motor capacity (kW)	Power consumed (kW)		Power Factor	Average Power consum -ption (kW)
	No load	load		
38.5	20	40	0.6	22

Table 8.1 Load demands of hydraulic presses.

From the above table, it is clear that the motors have both low load factor as well as power factor. although the exact load pattern is not very clear, nevertheless it is suggested that measure to improve individual motor power factor to be taken (i.e capacitor connected at the motor control cubicle). This measure will reduce the motor copper losses.

There are many motor (total capacity 266 kW) used by the three kilns. These motor consumed only 51 kW of power which represent a load factor of less than 0.2. Even though most of these motors are in continuous operation in our opinion they are overdesigned. Considering the low power factor of 0.56 obtained during measurements, the ideal combined rating of all motors used by the kiln should be around 100 kW. It is recommended that the factory make a thorough individual check on all the load of motors and make appropriate action to replace the motor commensurate with the maximum load requirements. So that losses could be reduced, by the total motors efficiency will be incresed about 3 %, together with power factor improve from 56 % to around 80 % . These measures are estimated yearly in electric energy as follows;

improved efficiency of motors

$$= 51 \text{ kW} \times 0.03 = 1.53 \text{ kW}$$

improved power factor of motor

$$= 51 \text{ kW} \times 0.03 \times \left\{1 - \left(\frac{0.56}{0.80}\right)^2\right\} = 0.78 \text{ kW}$$

There fore the annual saving is;

$$(1.53 = 0.78) \times 24 \times 365 \times 0.23 = \$4654/\text{year}$$

where 51 : actual loads (kW) of 3 kilns motors.

0.03 : recommended increasable efficiency of 3 kilns motors.

0.56 : actual power factor

0.80 : recommended power factor of 3 kilns motors.

24 : working hours/day

365 : working days/year

0.23 : cost of electricity/kWh

8.3 <u>Lightings</u>

Overall factory lighting is good except places where additional lightings are required;

(a) office stairs where only 30 lux luminosity was registered, this situation is considered dangerous.

(b) the agitator room.

9 Summary

9.1 Thermal part

According to the diagnosis of this project, the performance skill for tile manufacturing using the tunnel kiln in this factory has been considerably resonable comparing to the similar ceramic industories in Japan. If we dare pick up the items to improved on the energy conservations, the expectant measures are listed up as follows ;

(1) 1st. Phase Measures (no or little investment)

		Annually fuel saving %	$
(a) O_2 content control from 7.4% to 5 %	about	1	12,000

(2) 2nd. Phase Measures (some investment)

	Annually fuel saving %	$
(a) Extensive insulation surface of tunnel kiln	8 to 10	200,000

(3) 3rd. Phase Measures (large-scae process change)

9.2 Electrical parts

In section 8. we have made the following recommendations with accumulated total saving in energy per year of $25220;

(1) Reduction in the size of transformer.

(2) Lowering of operating voltage.

(3) Partial change in the mode of power factor correction.

(4) Reducing the size of motors using in the kilns section.

Out of the four recommendation (2) requires no investment and should be carried immediately and remainder of the recommendations require some investment.

MALAYA INDUSTRIAL AND MINING CORPORATION BHD.

1. Outline of the Factory

Address: Batu Caves, Selangor, Malaysia

Capital: 15,000,000 Malaysian dollars

Type of industry: Cement

Major products: Portland cement

Annual output: 62,700 t

No. of employees: 80

Annual energy consumption:

- Electric power, 7,500,000 kWh
- Fuel, fuel oil, 7,000 kℓ and diesel oil, 193 k

Interviewees: Mr. Lim Yen Heat, Factory Manager
Mr. Lim Eng Seong, Chief Chemist and
two engineers

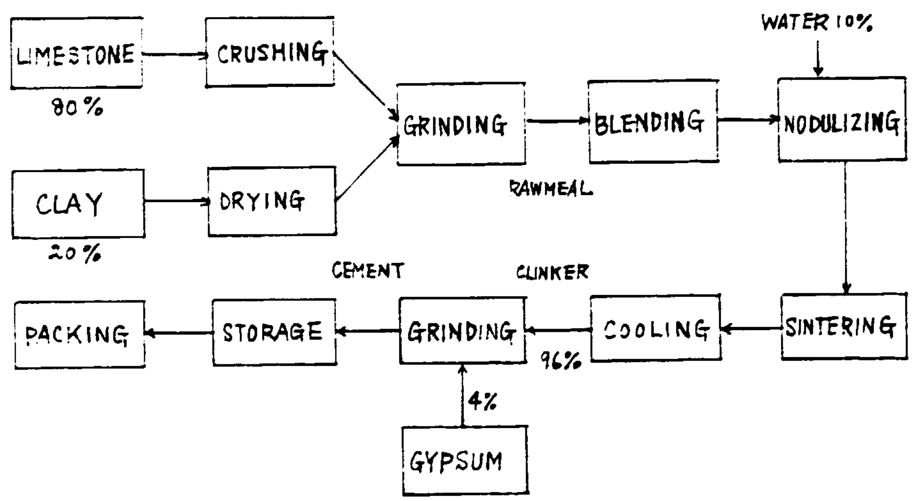
Date of diagnosis: Apr. 14 - 15, 1983

Diagnosers: Mr. M. Eguchi, Mr. R. Takahashi, and
Mr. T. Sugimoto

Counterparts: Dr. Mohd Ariff Araff, Dr. Ong Peng Su,
Mr. Ahmed Faizul, and Mr. Alizan Ab.
Manan

- The factory is located in Batu Caves which is about 11 km north of Kuala Lumpur. The production started in 1959.
- The Batu region shows the exposure of limestone over the whole area, and is situated in the southernmost position of the Asian Continent. The factory is most favorably located with the mining claims of the limestone, which constitutes 80% of the raw materials for cement.

2. <u>Manufacturing Process</u>

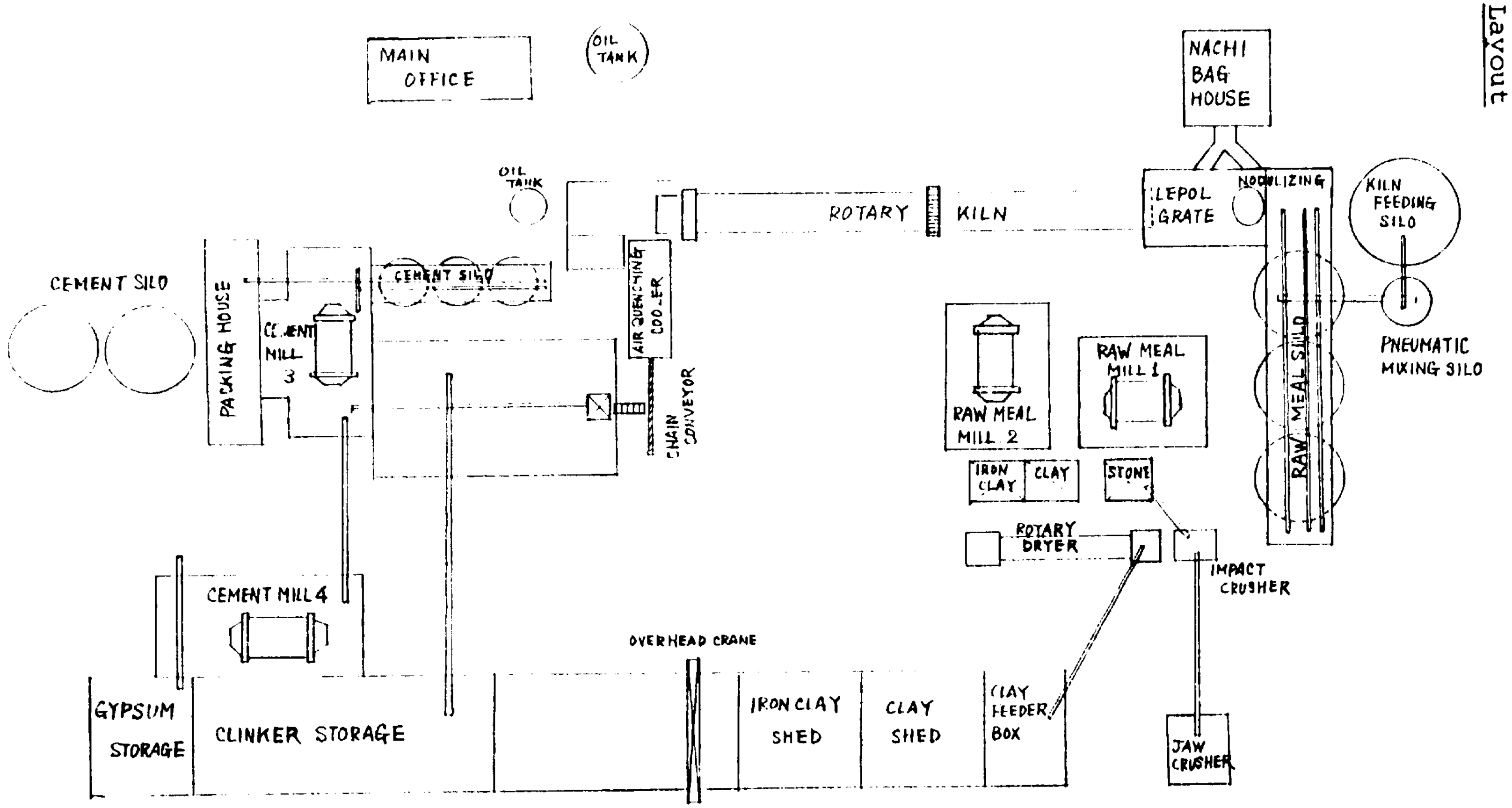


3. Major Equipment

3.1 Major Equipment

Name	No. of Units Installed	Type, etc.
Rotary dryer	1	Kind of energy used: Heavy fuel oil Nominal output: 4 t/h
Rotary kiln	1	Type: Lepol grate type Kind of energy used: Heavy fuel oil Nominal output: 200 t/day
Mixing plant	1	Pneumatic mixing system

3.2 Layout



MAIN OFFICE
OIL TANK
NACHI BAG HOUSE
OIL TANK
ROTARY KILN
LEPOL GRATE
NODULIZING
KILN FEEDING SILO
CEMENT SILO
PACKING HOUSE
CEMENT SILO
AIR QUENCHING COOLER
CEMENT MILL 3
CHAIN CONVEYOR
PNEUMATIC MIXING SILO
RAW MEAL SILO
RAW MEAL MILL 2
RAW MEAL MILL 1
IRON CLAY
CLAY
STONE
ROTARY DRYER
IMPACT CRUSHER
CEMENT MILL 4
OVERHEAD CRANE
GYPSUM STORAGE
CLINKER STORAGE
IRON CLAY SHED
CLAY SHED
CLAY FEEDER BOX
JAW CRUSHER

4. Situation of Energy Management

- The energy cost to the turnover amounts to 48.9%. This is the reason why the factory manager and key personnel have a strong concern for energy-conservation.
- However, there is no organization and system, nor is there a target for energy-conservation.
- The company installed a nachi filter for the improvement of production facilities. But now, there is no other specific plans. The company is willing to invest in energy-conservation provided that the pay-back period is less than a year.
- Fuel consumption is checked by the flow meter set on the rotary kiln. Reading of the meter is done hourly, and records are kept. The energy consumption rate is calculated daily, and cost accounting is made monthly. But, there is no examination made through a control chart as generally done in Japan.
- It is said that workers' consciousness of energy-conservation is very low. But, there is no training program directed to general workers. Nor, there is any PR done by the factory manager toward workers.
- Heat release is very large from the outer surface of the combustion chamber of the dryer, the rotary section of the combustion room and that of the rotary kiln. It is necessary to consider to provide the lining of ceramic heat insulation material.

. The burner of the dryer is of an oil pressure nozzle type, in which atomization is very poor. So, it is feared that imcomplete combustion is caused with long flame. It is necessary to improve the combustion by changing the burners.

5 Situation of Fuel Consumption

The factory is purchasing about 6,433 tonne of fuel oil annually. The clinker production process consums 92 % of the total purchasing fuel oil, while the remaining 8 % of fuel is consumed by drying process.

5.1 Rotary Dryer

5.1.1 Operating and Measured Data

(1) Fuel Oil Specification

(a) A class of fuel	Heavy fuel oil
(b) Gross heating value	42.4 MJ/kg
	10129 kcal/kg
(c) Specific gravity	0.99
(d) Composition	C 84 % H 12 % S 4 %

(2) Input Condition

(a) Feed rate of raw material	3 tonne/hr (dry basis)
(b) Feed rate of fuel oil	0.1 tonne/hr

(3) Drying condition

(a) Raw clay moisture content before dryer	18 %wt.
(b) After dryer	5 %wt.

(4) Flue gas condition (observed)

a) O_2 content	12.5 %
b) Temperature in exhaust duct	172 ^{o}C

5.1.2 Heat Balance for Rotary Dryer Operation

The heat balance for rotary dryer operation based on above data and additional of the surface temperatutre of rotary dryer is calculated as next page ;

Description	Input		Output	
	kcal/kgfuel	%	kcal/kg fuel	%
Input				
Heavy fuel oil	9,500	100.0		
Output				
Heat content of discharged product			1,431	15.1
Latent heat of evaporated water			2,573	27.1
Dispersion heat loss			3,404	35.8
Flue gas heat loss			1.162	12.2
Balance (uncountable)			930	9.8
Total	9,500	100.0	9,500	100.0

Table F.5.1 Heat Balance Sheet for Dryer Operation

5.2 Cement Clinker Production Plant

Clinker production plant consists of Lepol station for preheating of the clay pellets as raw materials after pelletizer, the main rotary kiln for the production of clinker and the air quenching grate type cooler to cool the clinker discharged from the rotary kiln at 1 200 °C to 250 °C.

At first, the heat balance sheets of individual process are calculated based on the operation and observed data, and finally, the overall heat balance sheet is summerized for presentation of the procedure to prepare the heat balance sheet. These heat balance sheets are very useful on the detection where the energy is wasted.

5.2.1 Ooerating and Measureed Data

(1) Fuel Oil Soecification

Same as the fuel for the dryer.

(2) Input Condition

(a) Feed rate of raw material(dried basis)		320 tonne/day
(b) Composition of raw material dryed basis)		
$CaCO_3$	80 %	256 tonne/day
Clay	20 %	64 tonne/day
(c) Moisture content of pellets as raw material		
10 % of dry pellets		32 tonne/day
(d) Feed rate of fuel oil		875 kg/hr

(3) intering Condition

(a) Sintering temperature for clinker in rotary kiln 1,450 °C

(b) Temperature of discharged clinker 1,200 °C

(4) Flue Gas Condition from Rotary Kiln

(a) O_2 content 5.7 %

(b) Temperature of flue gas at kiln outlet 900 °C

(5) Flue Gas Condition from Suction Chamber of Leool Station

(a) O_2 content 15.2 %

(b) Temperature of Lepol outlet gas 170 °C

(6) Production rate of Clinker oer Hour

8.788 tonne/hr

5.2.2 Heat Balance of Clinker Production Plant

The heat balance of individual orocess on clinker production plant are shown as follows ;

(1) Lepol Station

Description	Input		Output	
	kcal/hr	%	kcal/hr	%
Input				
Di charged Gas from Rotary Kiln	4,453,000	100.0		
Output				
Discharged Gas from Lepol Station			1,854,000	41.6
Heat content of pellet to Rotary Kiln			1,394,000	31.3
Dispersion Heat Loss			204,000	4.6
Latent Heat of Water inPellet			734,000	16.5
Balance(uncountable)			267,000	6.0
Total	4,453,000	100.0	4,453,000	100.0

Table F.5.2 Heat Balance Sheet for Lepol Station

(2) Rotary Kiln

Description	Input		Output	
	kcal/hr	%	kcal/hr	%
Input				
Fuel	8,225,000	66.1		
Inlet Air from Cooler	1,940,000	15.6		
Heat Content of inlet Pellet from Lepol	1,394,000	11.2		
Exothermic heat of Reaction for clinker	879,000	7.1		

to be continued on next page

Description	Input		Output	
	kcal/hr	%	kcal/hr	%
Output				
Heat Reaction for Decomposition of $CaCO_3$			4,174,000	33.6
Exhaust gas Heat Loss fron kiln to Lepol			4,453,000	35.8
Discharged Clinker from Kiln to Cooler			2,566,000	20.6
Dispersion Heat Loss from Kiln Surface			736,000	5.9
Balance			509,000	4.1
Total	12,438,000	100.0	12,438,000	100.0

Table F.5.3 Heat Balance Sheet for Rotary Kiln

(3) Rotary Kiln

Description	Input		Output	
	kcal/hr	%	kcal/hr	%
Input				
Heat Content of Clinker from Kiln	2,566,000	100.0		
Output				
Discharged Clinker			421,000	16.4
Exhaust Gas to Stack			279,000	10.9
Hot Air recovering Heat from Cooler to Kiln			1,940,000	75.6
Dispersion Heat Loss			34,000	1.3
Balance (uncountable)			- 108,000	- 4.2
Total	2,566,000	100.0	2,566,000	100.0

Table F.5.4 Heat Balance Sheet for Air Quenching Cooler

(4) Overall Heat Balance for Clinker Production Plant

Description	Input		Output	
	kcal/hr	%	kcal/hr	%
Input				
Fuel Oil	8,225,000	90.3		
Exothermic heat of Reaction for Clinker	879,000	9.7		
Output				
Discharged Clinker			421,000	4.6
Exhaust Gas from Cooler to Stack			279,000	3.1
Heat of Reaction for Decomposition of $CaCO_3$			4,174,000	45.8
Latent Heat of Water in Raw Pellets			734,000	8.1
Discharged gas from Lepol Station			1,854,000	20.4
Dispersion Heat Loss of Surface of ;				
Lepol Station			204,000	2.2
Rotary Kiln			736,000	8.1
Air Quenching Cooler			34,000	0.4
Balance (uncountable)			668,000	7.3
Total	9,104,000	100.0	9,104,000	100.0

Table F.5.5 Overall Heat Balance for Clinker

6 Problems in Thermal Energy Utilization and their Potential Solutions

The fuel consumption ratio (kg of fuel/ tonne of prod.) of the fuctory is 99.6 kg of fuel/tonne clinker. The cement production factories using Lepol station in Japan have average fuel consumption ratio of 91.7 kg of fuel/tonne of clinker. Such fuel consumption ratio of this factory is only slightly higher than average value in Japanese cement industry.

6.1 Rotary Dryer

6.1.1 Combution Control

The flue gas of dryer O_2 content of 12.5 % and this combustion situation could be improved by reducing the O_2 content in flue gas to 5 % provided there is no smoke formations. The reduction of O_2 content in exhaust gas owe to control intake air for combustion would give the savings of 5 to 6 % of fuel consumption on the dryer. This saving of fuel is annually equivalent to about 14,000 $ to 16,000 $

6.1.2 Extensive Insulation

The inner surfaces of cylinder of rotary dryer are completely not insulated which result in high heat loss from surfaces It would be better to install the insulating brick on the inner surface of rotating cylinder with proper thickness. In present it is difficult to estimate the effect of savings because of the lack of suitable data and survay time.

6.2 Cement Rotary Kiln

Refering to the operational data on Japanese cement industries, the fuel consumption on rotary kiln operation is almost reasonable.

6.2.1 Restriction of air flowing into suction zone of Lepol Station

In suction zone on Lepol station, ambient air considerablyis sucked resulting in to lower the temperature of the atmosphere of pellet inlet space. It would be better to close the opening located on case of station as many as possible, as to heat up the cold pellet to higher temperature as posible, provided that heated pellet is no effect.

6.2.2 Alternative resource for preheat of fuel oil

The supplying systems of fuel oil to the burner of rotary kiln is equipped with electric oil heaters. The required energy for electric heating of fuel was equivalent to 40 kw. If waste heat, for example, from the air quenching cooler is utilized instead of the electricity, an amount of saved electricity is estimated to be about $ 60,000 annually.

7. Electricity

7.1 Electrical consumption chracteristics

- supplier : National Electricity Board of the States of Malaya
- contractual maximum demand : 1000 kW
- average monthly consumption : 548 x 10 kWh
- factory load factor : 0.54
- contractual power factor : 0.85
- rated supply voltage : 415 volts
- transformer capacity : 2 x 1000 kVA

7.2 Schematic diagram and outline

Electrical schematic diagram is as shown in figure 7.1. This factory manufactures portland cement. The major loads are one rotary kiln, four grinding mills and two blower exhausts. The source is through 2 x 1000 kVA, 3 phase transformers of which one is very lightly loaded. Majority of the motors are made up of large and medium size 3 phase induction motors numbering total of 120 and combinned capacity of 1650 kW. Most of the large size motor have load factor of 0.6 to 1.0 which are considered reasonable for this industry.

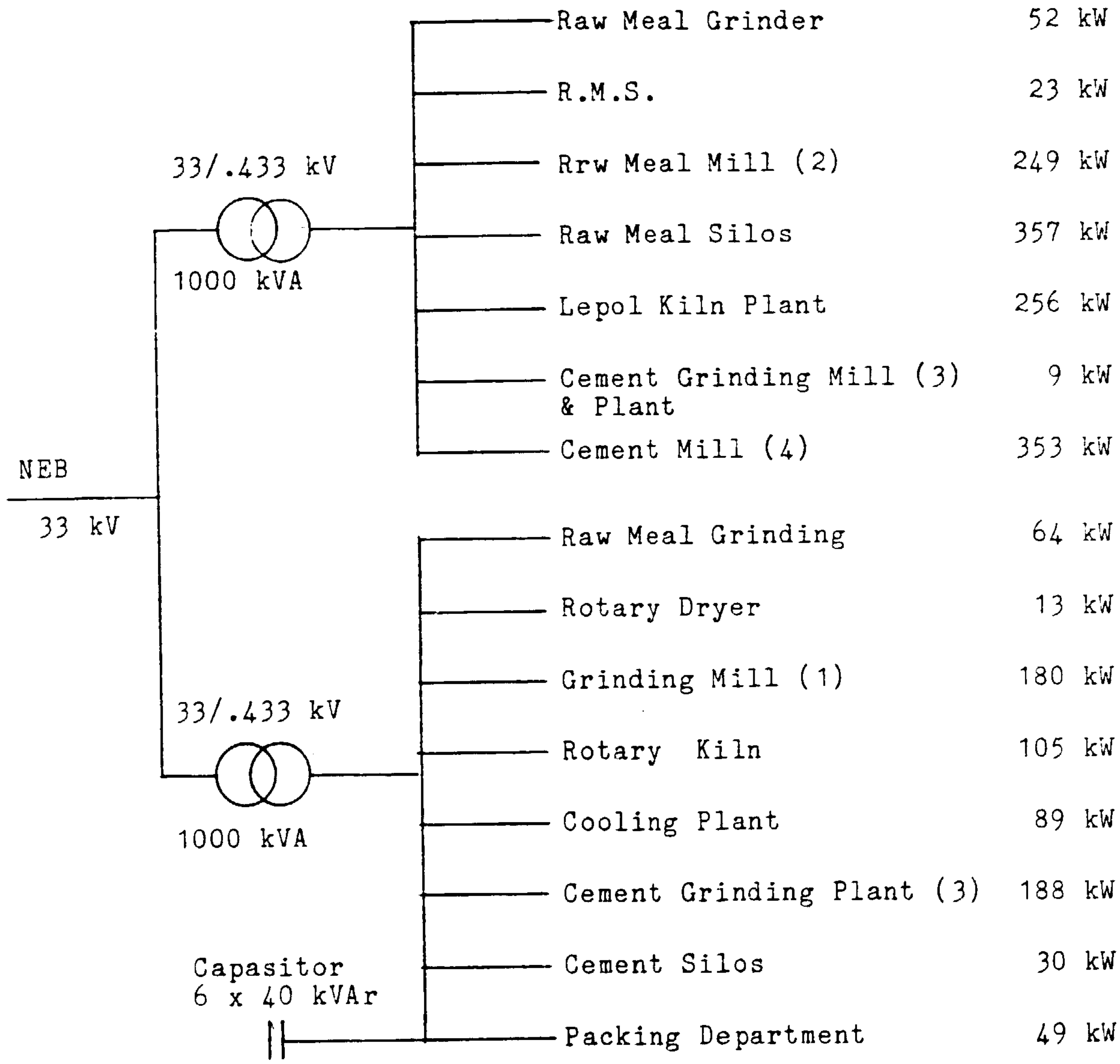


Figure 7.1 Electrical schematic diagram of MALAYA INDUSTRIAL MINING CORP.

8. Problems in electric power utilization and their potential solutions

8.1 Source

8.1.1 Transformers

The factory transformer capacity total 2000 kVA and the load registered as shown in the table 8.1.

The transformer No. 1 is suitably loaded whith load factor 0.79, however transformer No 2 is under utilised with a load factor of only 0.31. It is suggested that the total transformer installed capacity be reduced to 1500 kVA of preferably by 2 x 750 kVA transformers and operated in parallel with the 500 kVA reduction in the installed transformer capacity an energy saving of $2418/year can be realized, as shown by the following calculation.

saving/year,

$$= \left\{2 \times 1000\ (1-0.985) - 2 \times 750\ (1-0.984)\right\} \times 0.2 \times 24 \times 365 \times 0.23 = \$2418/\text{year}$$

where

1000	:	existing transformer capacity
750	:	recommended transformer capacity
0.985	:	efficiency of 1000 kVA transformer
0.984	:	efficiency of 750 kVA transformer
0.2	:	iron loss factor
24	:	working hours/day
365	:	working days/year
0.23	:	cost of electricity/kWh

8.1.2 Voltages

The measured voltages for the two transformers are 422 volts for transformer No 1 and 441 volts for transformer No 2 against the motor rating 400 volts to 415 volts. It is recommended that the transformer voltages be lowered to the lower rating of the motors, i.e, 400 volts. It is generally accepted facts that motors used in this type of industry, lowering the supply voltage will results in increase motor efficiency and also improve power factor.

According to the log book of the factory it is indicated that when the factory is not fully loaded (8.00 am) the supply voltage is about 430 volts and when the factory is on full load (9.00 am), the supply voltage is about 412 volts. This voltage is considered significant and corrective actions should be taken to improve the factory voltage regulation.

8.1.3 Power factor

The power factor on transformer No.2 is very high, about 0.98 at full load. It is possible that the power factor would be leading at base load. This is due that the capacitor of power factor correcting equipment installed for this transformer is too large for the network connected to it. This undesirable condition can be rectified by removing some of the centralised connected capacitors and install separate capacitor banks for individual large motors. These capacitor bank should be switched in parallel with the motors simultaneously.

8.2 Electrical loads

8.2.1 Unbalanced loading

For transformer No. 2, the current as measured shows about 13 % unbalanced loading. This large unbalanced condition in the load current resulted in unbalanced voltage of about 5 %. This condition introduces reverse torque and vibration in the motors which reduce the efficiencies of the motors and increase maintenances on motor bearings to excessive vibration and heating. It is recommended that the factory conduct a thorough investigation of the electrical load distribution and to redistribute the phasal loads equitably to restore the balance conditions.

8.2.2 Large motors

In accordance to the name plates of the various are as shown in table 8.1 below.

Description of Motors	Rating		Actual measurements			Load factors
	power (kW)	voltage (V)	power (kW)	voltage (V)	power factor	
Grinding No 2	160	400	130	433	0.87	0.81
Grinding No 3	150	400	157	432	0.91	1.05
Cement Grinding	230	400	210	418	0.84	0.91
Exhaust No 3	110		97	418	0.77	0.89
Roots Blower	75		56	430	0.84	o.74
Total			650			

Table 8.1 Ratings and loadings of large motors

The grinding and the exhaust motors have low power factor (between 0.7 to 0.84). It is also observed that the voltage at the motor terminals for this two types of motors are also very low in spite of the comfortable supply voltage of 418 volts. Therefore it is sugested that the factory should look into the ratings and sizes of the wirings of the motors. Further power factor correcting capacitor should be installed for these motors as recommended earlier.

8.2.2 Continuously running of motors and maintenance

It was observed that the factory is working in a continuous shift basis (24 hours/day) and very often a lot of machines are running continuously. This situation make maintenance scheduling very difficult. Nevertheless we have also observed that many motors are running without any load connected to it, and some motors are still running even when the beltings are already snaped. This leaves to the conclusion that the factory has very poor maintenance procedure. This practice is very wasteful and should be avoided to save energy. We recommended, therefore that a systematic maintenance schedule to be drawn for the electrical installations and for those mortors which are completely indispensable duplicate system should be installed.

For motors larger than 50 kW we would also recommended to provide simple automatic no load alarm systems be installed to enable the operators to swich off the motors as soon as they are no longer required for the process. Even allowing for only about 30 minutes of idling time per day for each motors a saving of about \$29656/year can be realised as shown below;

saving = 650 x 0.5 x 365 x 0.25 = \$29656/year

where 650 : conbined rating in kW of large motors

0.5 : idling time in hour/day

365 : working days/year

0.25 : cost of electricity/kWh

8.2.3 Compressors

The factory has two air compressors that are not suitably located such that hot air is used as the intake air into the compressors. Since hot air intake reduces the efficiency of the compressor it is suggested that either the intake channels be located at a suitable place (outside the factory) or resite the location of the compressors. We also observed that the two compressors are work intendem such that both compressors are switched on and off simultaneously. In our opinion it would be better to redesign the compressed air system based on two compressors of smaller capacity where one will be operating continously and the other intermittently, thereby save energy on motor losses.

8.2.4 Heaters

For fuel oil heating the existing system used 60 kW electic heater. Our calculation shows that only 40 kW heater will be sufficient for the factory (See Heat Section). However we feel it would be more appropriate and economical to replace the electric heater, with that of heat exchange utilizing waste heat from other processed in the factory (see recommendation in Heat Section).

Further measure such as insulating the fuel tank with lagging material will reduce heat losses and further saving in energy. If all these measures are taken only

22 kW heat equivalent will only be necessary to heat the fuel oil to the required temperature. As an example for every 8 kW reduction in energy requirement will save about $17500/year.

8.2.5 Lightings

It was found that the factory spaces were very poorly lighted and is considered unsafe for working. We strongly recommend that more lightings to be installed and proper lighting cleaning schedule to be implemented.

8.3 Maintenance

As mentioned earlier the factory maintenance system need improvement and that machines should be kept clean and belting should not be allowed to slack which can introduce belt slipping, thus causing heating, belt snapping and wastefull operation of motors, etc. It is important to note that for each kilowatt save is equivalent to saving of $2190/year on energy cost

9 Summary

9.1 Thermal part

The fuel consumption ratio for the cement clinker manufacturing using Lepol station in this factory was found to be resonable comparing to the data of similar cement industries in Japan.

Fuel savings can be achieved by the following measure ;

(1) 1st. Phase Measures (no or little investment)

	Annually fuel saving %	$
(a) O_2 content control in combustion of rotary dryer	5 to 6	about 14,000
(b) Control of air intake at the suction zone of Lepol station	-	-

(2) 2nd. Phase Measures

	%	$
(a) Extensive insulation of rotary dryer	-	-
(b) Preheating of fuel oil using waste heat	-	60,000

(3) 3rd. Phase Measures (large-scale process change)

For furthersavings in fuel, the conventional study for replacement of process plant should be carried out, for example, "New Suspension Process".

9.2 Electrical parts

For this factory there are several avenues where energy saving can be achieved and in addition to improve working condition and factory management. The following major recommendations have been suggested;

(1) Reduction in transformer capacity to commensurate with the loading of the factory as suggested in 8.1.1.

(2) Install automatic no load alarm system for the large motors.

(3) To change electric heater for fuel oil with that of heat exchanger utilizing waste heat .

CHEMPAKA NEGRI LAKSHMI TEXTILES SDN. BHD.

1. Outline of the Factory

Address: Senawang Industrial Estate, Seremban,
Negri Sembilan, Malaysia

Capital: 30,000,000 Malaysian dollars

Type of industry: Textile

Major products: Textile yarn (cotton & blended)

Present output of major products per day:

45 s Polyester viscose 1,900 kg,

45 s Polyester cotton 400 kg

24 s Polyester viscose 2,250 kg,

32 s Polyester cotton 650 kg

No. of employees: 500

Annual energy consumption: Electric power, 7,560,227 kWh

Interviewees: Mr. Prem K. Sahgal, Factory Manager
Mr. Dinesh Agurwal, Spinning Master
Mr. Heblikar, Maintenance Engineer
Mr. Rao, Quality Control Officer
Mr. Rajen Dran, Asst. Maintenance Engineer
Mr. Farmy, Officer of Special Duty

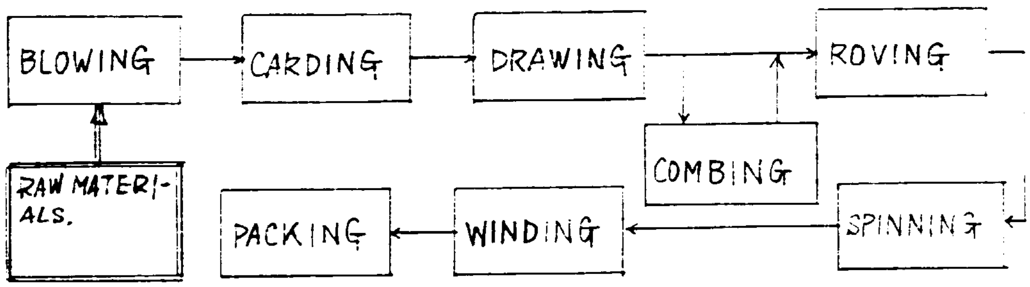
Date of diagnosis: Apr. 4 - 5, 1983

Diagnosers: Mr. M. Eguchi, Mr. R. Takahashi, and
Mr. T. Sugimoto

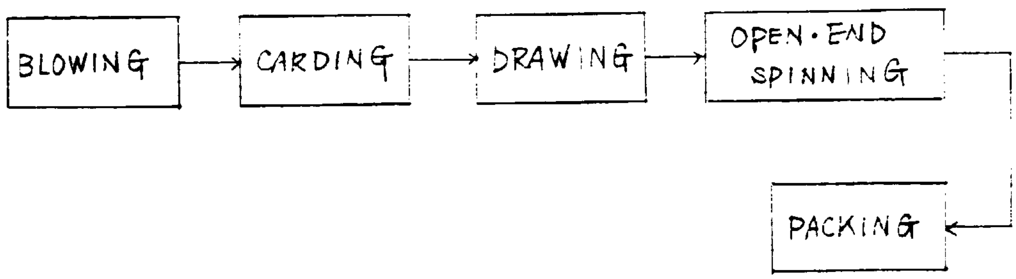
Counterparts: Dr. Mohd Ariff Araff, Dr. Ong Peng Su,
Mr. Ahmed Faizul, and Mr. Alizan Ab.
Manan

- The factory is located in Seremban, the capital city of Negri Sembilan, which is situated about 65 km southwest of Kuala Lumpur. A north-south highway links the city with Kuala Lumpur. The company is specialized in spinning.
- The company imports polyester from Japan, cotton from South America, Pakistan, and Singapore, and sells its products to nitting factories in the country.
- Energy is consumed only to operate airconditioners, compressors, motors, etc. no fuel is used.
- The key officers of the factory seem to have a strong concern for energy-conservation. The data of electric power consumption per equipment are well compiled, and kept in good order.

2. Manufacturing Process



WASTE PLANT

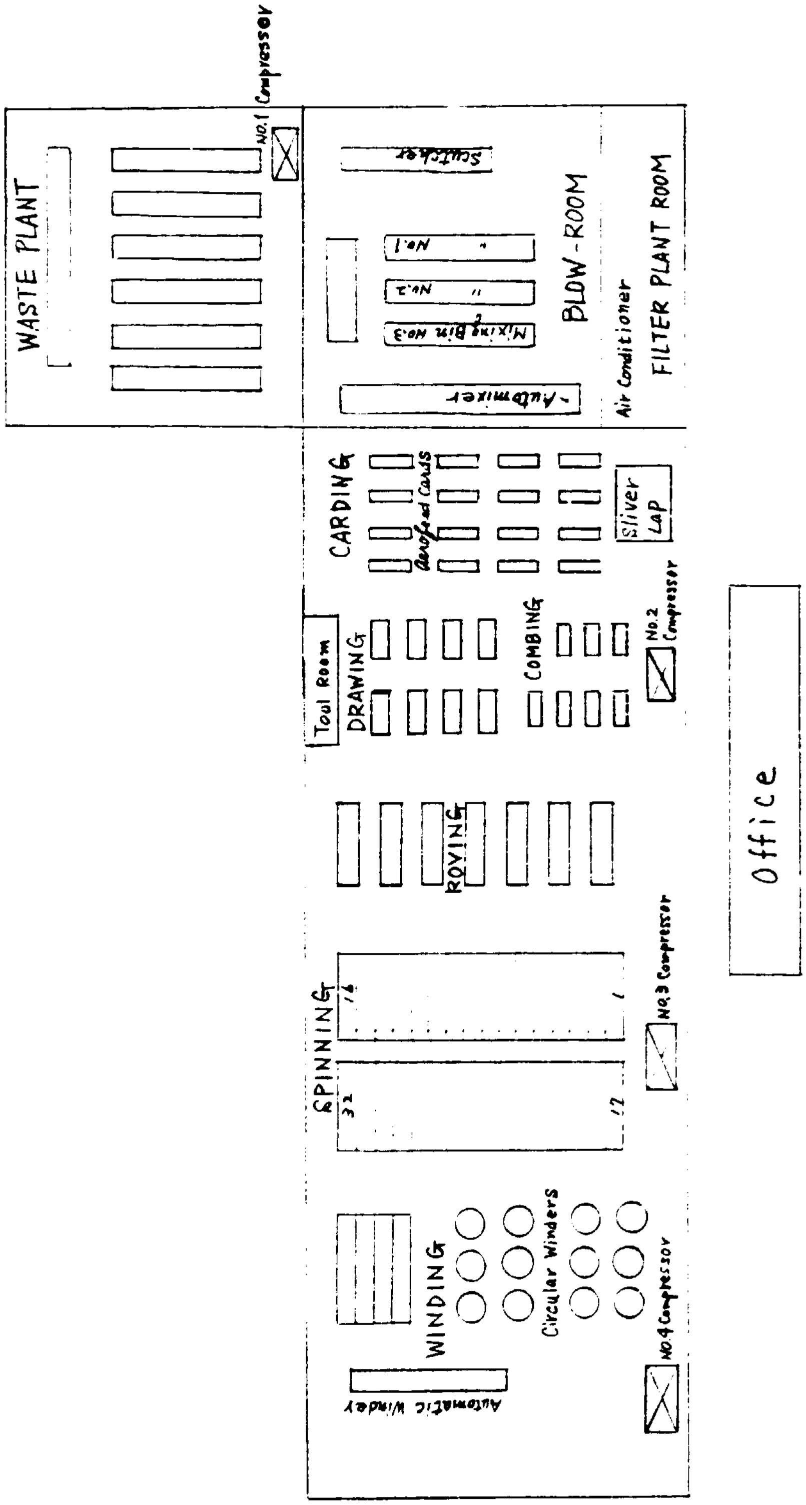


3. Major Equipment

3.1 Major Equipment

		No. of Units Installed
Blowing Machinery:	Scutcher	1
	Mixing Bin	3
	Automixer	1
Carding Machinery:	Aerofeed Card	16
Drawing Machinery:	Draw Frame	8
Combing Machinery:	Comber	7
Roving Machinery:	Simplex	7
Spinning Machinery:	Ring Frame	32
Winding Machinery:	Winders	4
	Circular Winder	12
	Automatic Winder	1
Compressors:		4

3.2 Layout


No.1 Compressor
WASTE PLANT
Scutcher
No.1
No.2
Mixing Bin No.3
BLOW-ROOM
Automixer
Air Conditioner
FILTER PLANT ROOM
CARDING
Aerofeed Cards
Sliver Lap
No.2 Compressor
Tool Room
DRAWING
COMBING
ROVING
Office
SPINNING
No.3 Compressor
WINDING
Circular Winders
Automatic Windey
No.4 Compressor

4. Situation of Energy Management

- Energy consumption is only in electric power. No fuel is used.
- The key officers have a strong concern for energy-conservation. They plan to establish concrete targets for the power saving ratio as well as the date of achievement.
- There is no organization for the promotion of energy-conservation.
- There is no training program directed to general workers. But, the staff members are made to attend seminars from time to time.
- The factory manager makes PR to general workers for energy-conservation. But, workers' consciousness is poor. There is also a suggestion box. But, no suggestion has been received so far.
- Daily recording is made on power consumption by equipment, production process, and factory. Recordings are compiled and kept in good order. The electric power consumption rate (kWh/kg. yarn) is obtained. And cost accounting is made monthly. These abundant data are kept in good order.
- As for power consumption, a substantial consideration is given to energy-conservation through measures including load measurement on transformers, improvement of power factor by condensers, etc. However, there are some unreasonable things being done including the installation of compressors which have a large heat release or the taking-in of exterior air in an air-conditioned room.

5 Situatiom of Fuel Consumption

6 Problems in Thermal Energy Utilization and their Potentioal Solutions

All the management of factory has been operated using only the electricity as energy source. Then the description on above items is eliminated.

7. Electricity

7.1 Electrical consumption chracteristics

- supplier : National Electricity Board of the States of Malaya.
- contractual maximum demand : 950 kW
- average monthly consumption : 557×10^3 kWh
- average factory load factor : 0.45
- contractual power factor :0.85
- transformer capacity : 2 x 1250 kVA
- rated supply voltage : 11,000 volts

7.2 Schematic diagram and outline of factory

Electrical schematic diagram is as shown in Figure 7.1. This factory consumed only electrical energy. The electrical energy management of the company viz input voltage, power factor, countermeasures against maximum demand and load balance is considered well. The factory installed 2 x 1250 kVA, 3 phase transformers and recieved supply at 11 kV. However the two transformers are lightly loaded and 38 % of the total load is consumed by the air conditioning equipments. The total installed motor capacity is about 900 kW, but actual power consumed by these motors is only 40 % and there are many motors which are rated below 25 kW.

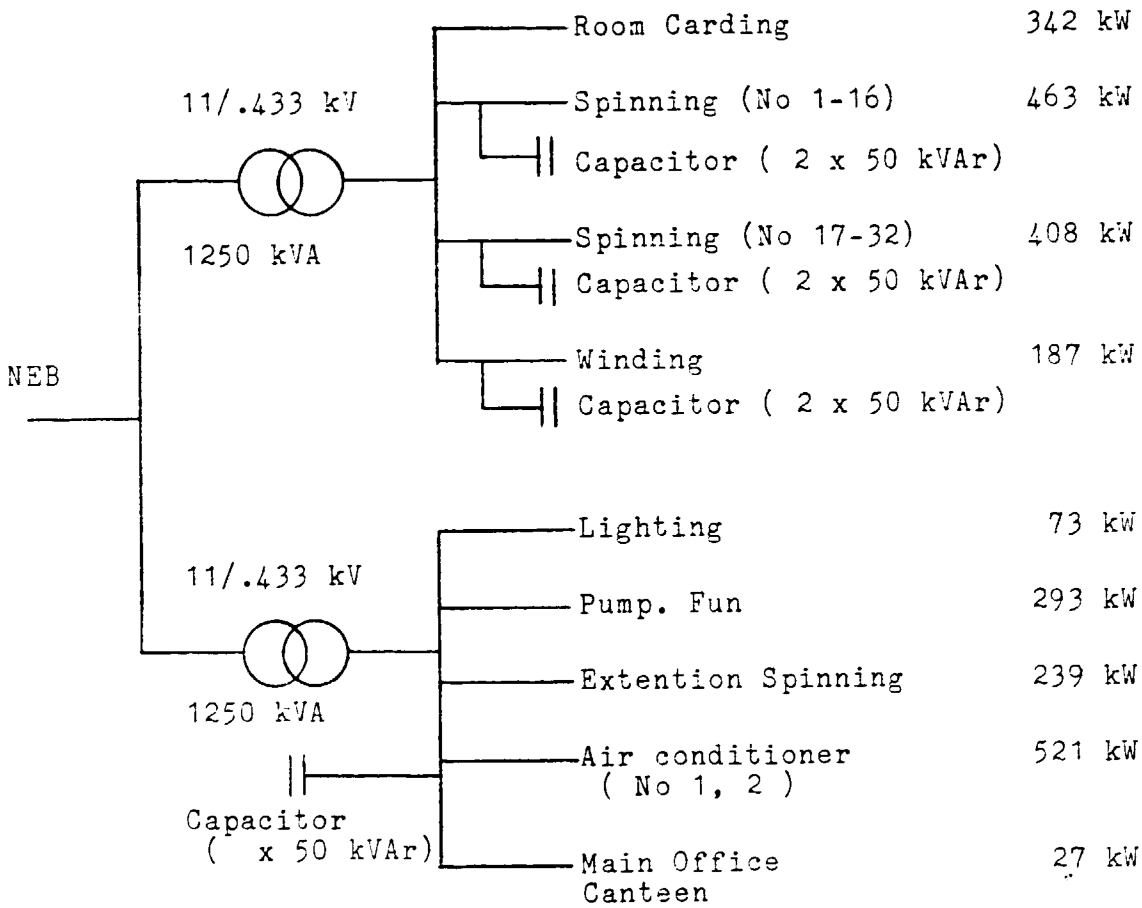


Figure 7.1 Electrical schematic diagram of CHEMPAKA LAKUSIMI TEXTILES SDN.

8. Problems in electric power utilization and their potential solutions

8.1 Source

8.1.1 Transformers

The total capacity as indicated before is 2500 kVA and the loads registed by these transformers are shown by table 8.1 below;

Description	Transformer No 1	Transformer No 2	Total
Capacity of Transformer(kVA)	1250	1250	2500
Installed load capacity (kW)	1400	1160	2560
Power taken by loads (kW)	450	450	900
Average monthly consumption (kWh)	332 x 10	370 x 10	702 x 10
Power factor	0.95	0.96	0.95
Actual consumption (kVA)	474	469	945
Calculated load factor	0.38	0.38	0.38

Table 8.1 <u>Transformer ratings and loading condition</u>

It is obvious that the transformers are under utilized with conbined load factor of only 0.38. It is recommended that the total transformer capacity be reduced to disconnecting one of the transformers and the whole of factory supply be connected to the other transformer. If such step is carried out the following cost of energy can be saved.

$$\text{Saving} = 1250 \times (1-0.986) \times 24 \times 365 \times 0.2 \times 0.17$$
$$= \$5212/\text{year}$$

where 1250 : rating in kVA of the transformer to be taken off.

0.986	:	eficiency of 1250 kVA transformer
0.2	:	iron loss factor
24	:	working hours/day
365	:	working days/year
0.17	:	cost of electricity /kWh

8.1.2 Voltage and power factor

The measured output voltage of the two transformers are about 421 volts and when compared against the various motor ratings, this value is considered reasonable. The factory keeps very good power factor (0.95) by installing individual capacitor for each motor for compensation.

8.2 Electric power consuming management

For transformer No. 2 a considerable unbalanced loading was measured (6.4 % unbalanced current i.e, 55 Amps neutral current). Therefore we recommend that the factory should redistribute the loads connected to this transformer to improve the balance condition.

During our visit the factory was not in full production. Therefore it is not possible for us to recommended the new contractual maximum demand value. It is recommend that the factory make a study on the maximum demand required during full production operation for the while and re-evaluate the value of contractual maximum demand. If the factory maximum demand is lower than the present contractual maximum demand, a renegotiation with the supplier on a new contractual maximum demand value should be carried out.

It is also suggested that a special alarm system to be installed for total consumed power indicator to prevent the factory operating beyond the contractual maximum demand.

8.3 Electrical loads

8.3.1 Air conditioning

This factory has two central air conditioning systems with refrigerators, pumps and blowers. The major data for the system are given bellow in table 8.2 and 8.3.

Description		Actual load (kW)	Average monthly consumption (Mar. 83')		Installed capacity (kW)
			(kWh)	% of total monthly	
Air condit-ioning	Refrige-ration	210	$163x10^3$	23	521
	Pumps and Blowers	141	$107x10^3$	15	293
	Total	351	$270x10^3$	38	814

Table 8.2 Data for air conditioning system

Description	Value
Room capacity	22000 M^3
No of work men	80
Power rating of lighting	40 kW
Power rating of operating machines	298 kW

Table 8.3 Major heat load data

It was found that there are several heat dissipating apparatus such as air compressors (3 units) and static capacitors located in air conditioned rooms. This practice increases the load on the air conditioners, and therefore it is strongly recommended that these heat dissipating equipments to be located in well ventilated and non air conditioned spaces. If such measures are carried out the following cost of energy can be saved.

Heat dissipated by 3 compressors /hr $= 7.5 \times 3\,(1-0.75) \times 0.5 = 2.8$ kWh/hr

where 7.5 : rating of compressor in kW

0.75 : efficiency of compressor

0.5 : diversity factor

Energy required by air condition plant to take away the compressor heat/hr $= 2.8 \times \frac{1}{0.7}$

$= 4$ kWh/hr

where 0.7 : efficiency of air conditioned plant

saving/year $= 4 \times 24 \times 365 \times 0.17 =$ \$5957/year

whre 24 : working hours/day

365 : working days/year

0.17 : cost of electricity/kWh

8.3.2 Motors

Some of the motors in the factory are lightly loaded (overdesigned). Generally the motors operating within 70 % to 80 % load factor give better efficiency and in this context, for these operating below 40 % load factor should be replaced by one, whose rating is appropriate for the load. The factory was found clear and maintenance system seems adequate. However the compressed system it is suggested that compressed air leakage be checked for distribution pipe and whole system periodically

8.3.3 Lightings

Most compartments and sections in the factory have good lighting system except in the spinning and winning section. where the light intensity at working position is only 150 lux. The usually lighting standard for this type of work is 300 lux (Japanese practise). Therefore it is recommended that the lighting fittings in these sections be lowered by 1.0 meter or extra lighting fittings be installed to achieve the lighting intensity for work efficiency and quality.

9. Summary

9.1 Tharmal parts

9.2 Electrical parts

For this factory the following recommendations were made for saving electrical energy.

(1) Operating with one transformer only.

(2) Reduce maximum demand load and utilizing maximum alarm indicator.

(3) Decreasing air conditioned load by relocating the dissipating equipments such as compressors and capacitors.

FUSAN FISHING NET MANUFACTURING BHD.

1. Outline of the Factory

Address: Jalan North Port, Port Kerang,
Serangor, Malaysia

Capital: 10,000,000 Malaysian dollars

Type of industry: Textile

Major products: Fishing nets, agricultural nets, ropes

Annual output: Fishing nets 400 t, agricultural nets 11,000 pieces, ropes 660 t

No. of employees: 350

Annual energy, consumption:

- Electric power, 3,000,000 kWh
- Fuel, fuel oil 168 kℓ

Interviewees: Mr. Choo Kok Keong, Factory Manager
Mr. Ralmah, Personal Manager
Mr. Tan Guan Seng, Senior Production Assistant
Mr. Yap Eng, Senior Supervisor
Mr. Phan Yoke, Electrical Engineer

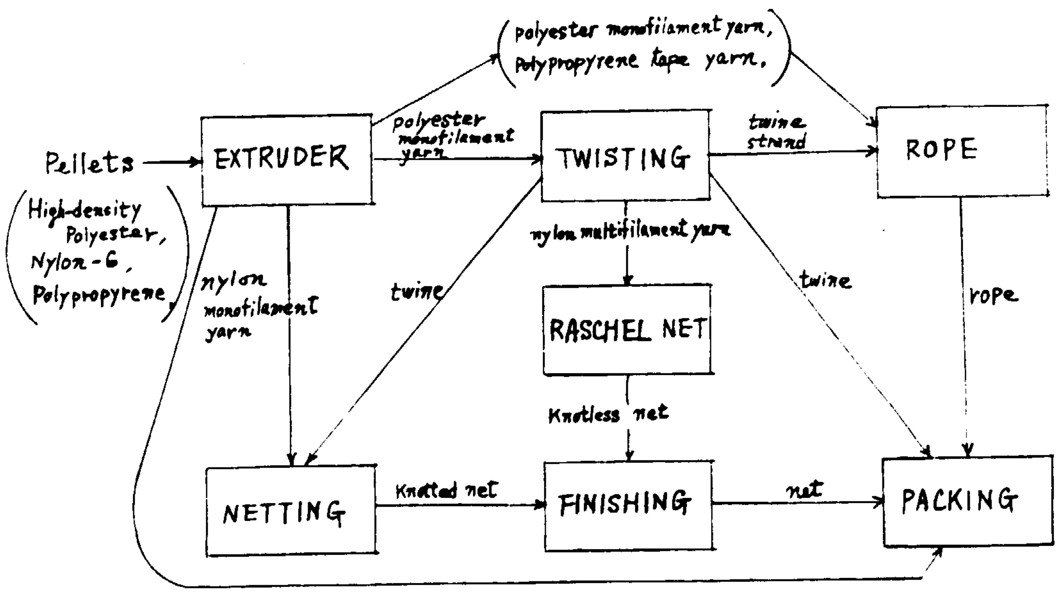
Date of diagnosis: Apr. 7 - 8, 1983

Diagnosers: Mr. M. Eguchi, Mr. R. Takahashi, and Mr. T. Sugimoto

Counterparts: Dr. Mohd Ariff Araff, Dr. Ong Peng Su, Mr. Ahmed Faizul, and Mr. Alizan Ab. Manan

- The factory is located in Port Kelang which is about 8 km from Kelang, an old capital of the state, which is situated about 32 km west of Kuala Lumpur.
- The company was established in 1967. And since 1968 the company has been engaged in the production of nets and ropes using nylon pellets, polyester pellets, polypropylene pellets as raw materials.
- There are two companies including this company in Malaysia producing fishing nets. Each of the two companies shares about 50% of the market.

2. Manufacturing Process

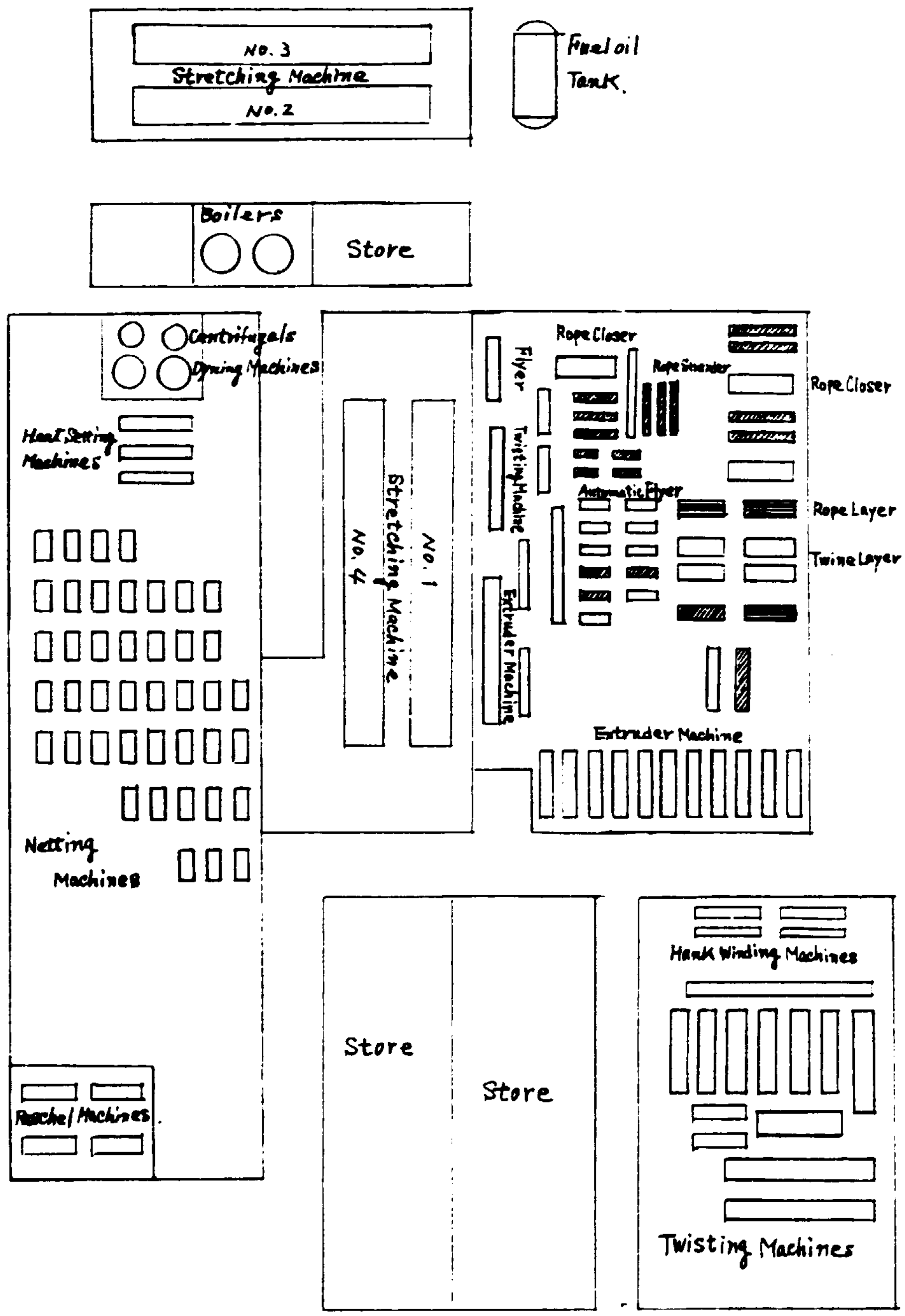


3. Major Equipment

3.1 Major Equipment

Name	No. of Units Installed	Type, etc.
Polyester monofilament extruders	12	Products: Polyester monofilament yarn Nominal output: 90 t/M Kind of energy used: Electrical
Nylon monofilament extruder	1	Products: Nylon monofilament yarn Nominal output: 10 t/M Kind of energy used: Electrical
Polypropylene tape extruder	1	Products: Polypropylene tape yarn Nominal output: 8 t/M Kind of energy used: Electrical
Heat stretching machines	3	Products: Fishing nets Nominal output: 50 t/M Kind of energy used: Electrical
Steam depth stretchers	2	Kind of energy used: Steam
Dyeing machines	2	Kind of energy used: Steam
Boilers	2	Old boiler Installed: 1968 Maker: The Kure Shipbuilding & Engineering Co., Ltd. Max. press: 10 kg/cm^2 New boiler Installed: 1973 Maker: Allen Ygnis Ltd. (London) Output: 3,000 lb/h Max. press.: 150 PSI (10.5 kg/cm^2)

3.2 Layout


No. 3
Stretching Machine
No. 2
Fuel oil Tank.
Boilers
Store
Centrifugals
Drying Machines
Heat Setting Machines
Netting Machines
Raschel Machines
No. 1
Stretching Machine
No. 4
Flyer
Twisting Machine
Extruder Machine
Rope Closer
Rope Stander
Rope Closer
Automatic Flyer
Rope Layer
Twine Layer
Extruder Machine
Store
Store
Hank Winding Machines
Twisting Machines

4. Situation of Energy Management

- There is no organization and system, nor any training and PR activity for energy-conservation.
- The company relies on the monthly bill to know the consumption of electric power and fuel. No measuring instrument is used. It will be necessary to confirm the quantities by scale at fuel receiving.
- Measuring of the exhaust gas temperature from the boiler and exhaust gas analysis was conducted for the first time since starting operation.
- There are a number of points for improvement such as the on-off (intermittent) operation of boiler, no recovery of steam condensate, etc. This means that the effect of energy-conservation, when achieved, will be great.
- Energy management is entirely new to this company.

5 Situation of Fuel Consumption

At a present the fuel oil in this factory is consumed by two boilers which are sometimes operated in parallel to each when the steam demand is high. During the low demand of steam the old boiler is shut dowm.

In 1982, the fuel consumption on the twe boilers was 168 kl per year. All the steam produced on the boilers was only utilized on the dyeing and stretching processes of fishing nets, while on the hot water baths at boiling condition in the extruder machines, the electricity to be extremely expensive energy has been utilized for only heating with the electric resistance elements. This heating systems should be improved by alternating the energy sources like as the steam or direct or indirect firing of fuel as soon as possible in order to save the operation costs.

5.1 Boiler Operation

5.1.1 New Boiler

(1) Operating and Measured Data

A) Fuel oil specification

(a) Sulphur content ;	2 %
(b) Gross heating value ;	18,500 btu/lb
	or 10,278 kcal/kg
(c) Annual fuel consumption	168 kl/year

B) Flue gas condition

(a) O_2 content	average 12.2 %
(b) Temperature	average 254 °C

C) Blow down procedure

(a) Period ; once in each 4 hours

(b) Water level indicator ; about 1 inch (25.4 mm) drop

D.) Steam condition

(a) Operating pressure 10 kg/cm^2g.

(b) Operating temperature 180 ^oC

(2) Heat Balance on New Boiler

The heat balance on new boiler in terms of per kg of fuel is estimated using above data as follows ;

Description	Input		Output	
	kcal/kgfuel	%	kcal/kgfuel	%
Input				
Fuel	9,580	100.0		
Output				
Flue gas heat loss			1,879.8	19.6
Dispersion heat loss			152.5	1.6
Blow down heat loss			232.6	2.4
Produced steam (from balance)			7,315.1	76.4
Total	9,580	100.0	9,580.0	100.0

Table H.5.1 Heat Balance Sheet on new Boiler

5.1.2 Old Boiler

(1) Operating and Measured Data

A) Fuel oil specification

Same as new boiler.

B) Flue gas condition

(a) O_2 content average 13.03 %

(b) Temperature average 257 °C

C) Blow down procedure

Same as new boiler

D) Steam condition

(a) Operating pressure 8.5 kg/cm²g.

(b) Temperature 175 °C

(2) Heat Balance on old Boiler

The heat balance on old boilor in terms of per kg of fuel is estimated using above data as follows ;

Description	Input		Output	
	kcal/kgfuel	%	kcal/kgfuel	%
Input				
Fuel	9,580	100.0		
Output				
Flue gas heat loss			2,191.9	22.9
Dispersion heat loss			261.0	2.7
Blow down heat loss			273.0	2.8
Produced steam (from balance)			6,854.1	71.6
Total	9,580	100.0	9,580.0	100.0

Table H.5.2. Heat Balance Sheet on old Boiler

5.2 Steam Consumption Facilities

5.2.1 Dyeing Machines

(1) Operating and Measured Data

A) Time schedule of dyeing operation

(a) Sorking time for dyeing per one batch		45 min.
(b) No. of dyeing processing per day and machine		16
(c) No. of total processing per day		32

B) Dyeing machine specification

(a) No. of dyeing machine		2 units
(b) Sorking temperature (amb. temp. ; 30 ^{o}C)		85 ^{o}C
(c) Volume of dyeing solution		1,000 litre
(d) Surface area of dyeing vessel	about	6.3 m^2

(2) Required Heat on one Batch Operation

(a) Heating up of dyring solution from 30 to 85 ^{o}C	55,000 kcal/batch
(b) Evaporation heat loss from free surface of solution	5,000 kcal/batch
(c) Dispersion heat loss from surfaces assuming $h = 20\ kcal/m^2hr^oC$	5,181 kcal/batch
(d) Total required heat neglecting reaction heat for dyeing	65,181 kcal/batch

(3) Amoult of Required Steam

(a) Heat released through the adiabatic expansionfrom 150 of steam to 85^{o}C of condensate to heat the dyeing solution — 571 kcal/kg

(b) The total consumption of steam per day for dyeing process

(65,181/571) x 32 = 36,53 kg of steam

5.2.2 Depth Stretching Machine

(1) Operating and Measured Data

A) Time schedule of depth stretching operation

(a) Sorking time per batch — 20 min.

(b) No. of total processing per day 30

3) Stretching machine specification

(a) Volume of Vessel 33.3 m^3

(b) Area of vessel cover 47.6 m^2

(c) Sorking temperature 100 °C

(d) Surface temperature of vessel cover 60 °C

(2) Required Steam on one stretching Operation

(a) Filling up in stretching vessel assuming twice steam of volume of stretching vessel

(33.3/0.3924) x 2 = 40 kg of steam/batch

where 0.3924 is specific volume of steam at 150 °C in m^3/kg.

(b) Dispersion heat loss 14 kg

(c) Heat content of fishing nets 0.2 kg

(d) The total required steam for one batch

40.0 + 14.0 + 0.2 = 54.2 kg

(3) The required Steam per day

54.2 x 30 = 1,626 kg/day

5.2.3 The Calculated Amount of Steam Consumed

3,653 + 1,626 = 5,249 kg/day

5.2.4 Average Amount of Generated Steam per day from Annual Fuel Consumption

a) Annual fuel consumption 168 kl/year

b) Annual working dats 291 days/year

c) Specific gravity of fuel 0.95

d) Assumed boiler efficiency approx. 70 %

e) Temperature of steam 170 °C

f) Total amount of steam ;

$(168,000/291) \times 0.95 \times 0.7 \times (10,278/631) = 6,253$ kg.

where 631 is the heat required to evaporate one kg of water at 30 °C to saturated steam at 170 °C.

It seems to be considerably reasonable in spite of the rough assumption. Refering to this results on the steam production and consumption, it seems that the only new boiler is sufficent to supply the reqired amount of steam to the steam consuming facilities.
According to the boiler instruction book, the new boiler has steam generating capacity of 3,000 lb/hr = 1,360 kg/hr. The rated output of steam for one day, 16 hours/day, continuously is resulting in to 21,770 kg of steam/day which is corresponding with about 3 times of actually generating steam in presents. Therefore, due to arrange the manufacturing schedule of stretching machine so as to match the demand to supply, the total steam requirment would be satisfied with only new boiler in loading factor of 60 to 70 %.

6 Problems in Termal Energy Utilization and their Potential Solutions

6.1 Boiler

6.1.1 Reduction of O_2 Content in the flue Gas

The O_2 content in the flue gas of new boiler is 12.2 % and of old boiler is 13.03 %. These show that both boilers are operated on high air ratio. some considerable effect for energy conservation should be expected according to reduce O_2 content in the flue gas by closing the air damper for secondary combustion air. However, some caution should be taken to prevent the generation of smoke from the stackes.

If O_2 content in the flue gas were reduce till 5 % which is recomendable value for the small package boiler using liquid fuel in Japan the savings in fuel consumption are 8 to 9 % on the new boiler and 10 to 11 % on the old boiler. These percentage of savings are equivalent to annually about $6,700 and $8,300 for respective boilers.

6.1.2 Decrease of the Temperature of Flue gas

At presents, the temperature of flue gas of both boiler inthis factry are about 250 to 260 °C These are clear on the value of recomendable criteria, 300 °C, in Japanese industries. Actually, the temperature of flue gas is affected by a lot of factors or undefined circumstance, that is, the loading factors, the degree of scales depositing on the surfaces outside and/or inside of the heating boiler tubes, the flowing linear velocity of combustion gas through the boiler tubes, so on. In practice nowadays almost of all factories having small package are endeavouring to reduce the temperature of flue gas as low as possible beyond criteria.

The most effective measures to reduce the temperature of flue gas will be to remove the scale attatched on the surface of inside and outside of the boiler tubes with the periodical overhaul of boiler bodies.

6.1.3 Boiler Water Quality Control

The values of PH and electric conductivity on the blow-down water from both boilers are clearing on its recomendable values in Japan which are 11.0 to 11.8 and 6,000 μs/cm respectivity. As a matter of fact, the blow-down operation of boilers in this factory was conducted without checking the PH and electrical conductivity of the the boiler water. In order to prevent the unnecessary blow-down which would cause chemical and heat losses, it is suggested that the boiler water quality should be measureed and the blow-down procedure should be improved periodically.

6.1.4 Continuous Operation of Boilers

The operation of only one new boiler to meet the dyeing and stretching steam demands would be sufficient as descrived in 5.2.4. To enable the continuous operation of new boiler, steam demand should be planned and continuous operation of boiler would reduce the fuel oil consumption. On case of suffering the troublesome planning, it would be better to install the well designed steam accumulator.

6.2 Steam Consumption Facilities

6.2.1 Installation of Partition Barrier in Stretching Vessels

The fishing nets with smaller length than 10 m are frequently processed for the finishings, although the stretching vessels have 20 m in lengths. In such cases the half space of vessels is not completely utilized and the filling up steam into such vacant space is more wastable, In order to reduce the steam consumption it would be recomendable to place a partition barrier on end of the fishnets so as to prevent the leakage of steam into unused vacant spaces.

Although it is difficult to estimate accurately the effects to save the steam, as a guess the savings would be roughly 10 % of the steam requirement of the stretching processes. Assuming that a chance of the processing non-full size nets is 50 %, Steam ratio is 10.84 kg of steam/ litre of fuel oil,and fuel oil price is $ 0.47/litre of fuel,the effect of the partition barrier would be equivalent to annualy about $ 1,000.

6.2.2 Lowering Operating Pressure on Boilers

The dyeing and stretching machine are operating at 85 °C and 100 °C respectively under atmospheric pressure. Considering to the basic energy conservation principle, it would be recomendable to be operated with as low pressure as possible. The present condition to be 8 kg/cm^2g. and 170 °C is too excessive.

Only as Reference

6.3 Extruder

6.3.1 Operating and Measured Data

(1) Size of Hot Bath

(a) Volume of bath ; 90 litre

(b) Free surface area of bath being exposed to ambent $0.16\ m^2$

(2) Make-up water rate $0.2\ m^2/8$ sec.

(3) Temperature of water in bath $100\ ^oC$

6.3.2 Estimation of Required Heat per unit Bath

(a) Dispersion heat loss approx. 1,020 kcal/hr

(b) Heat loss due to evapolation of water from uncoverd free surface. 2,700 kcal/hr

(c) Heat loss due to excess make-up water. 6,300 kcal/hr

(d) Total requirement of heat per unit bath 10,020 kcal/hr

This figure is equivalent to 11.65 kw

6.3.3 Possibility of Performance Cost Reduction in Extruder Processing

Though the final results are not obtained easly, as the common sence, it would be able to understand that 20 to 30 % of total expences of electricity consumption for the extruder processing are saved according to substitute the electricity for another energy sources.

7. Electricity

7.1 Electrical consumption characteristics

- supplier : National Electricity Board of the States of Malaya
- contractual maximum demand : 550 kW
- average monthly consumption : 246.5×10^3 kWh
- average factory load factor : 0.63
- contractual power factor : 0.85
- transformer capacity : 1000 kVA
- rated supply voltage : 415 volts

7.2 Schematic diagram and outline of factory

Electrical schematic diagram is as shown in Figure7.1.

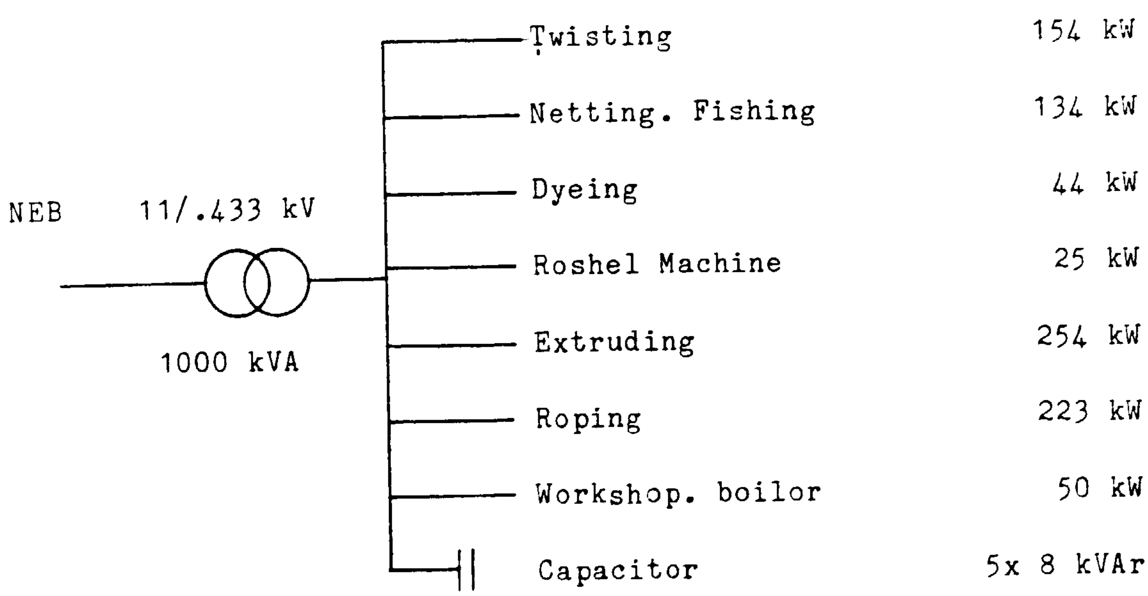


Figure 7.1 Electrical schematic diagram of FUSAN FISHING NET MFG. BHD.

This factory produces fishing nets and nylon ropes. Except for steam energy which is used for curing and dyeing purposes the remainder of energy requirement of the factory is provided by electricity. Major installed equipments are extruders, roping and netting machines and electrical heaters. The electric source is a 1000 kVA, 3 phase transformer.

8 Problems in electric power consumption and their potential solutions.

8.1 Source

8.1.1 Transformer

The factory average loading is 550 kW (640 kVA assuming 0.86 power factor) and transformer capacity is suitable.

8.1.2 Voltage

Most of the equipments are rated between 415 volts and 420 volts, but the actual supply voltage measured was 440 volts. It is therefore recommended to lower the supply voltage down to 420 volts. This measure will certainly reduce losses and improve power factor.

8.1.3 Power factor correction equipments

As mentioned earlier. The factory power factor is about 0.86. This power factor is still considered low in spite of the use of capacitor bank. Our measurements also indicate that the capacitors are worsened (consumed large power about 420 watts each), which makes them very hot. Therefore it is suggested to change the capacitors with that of more efficient ones. Accoding to Japanese industrial standard (JIS C 4902 (1977)) all capacitors for this purpose and at the rating as installed in the factory should have losses less than 175 watts each. If such measure is taken the effect in electricity cost can be calculated as follows,

Saving/year = (0.42 - 0.175) x 5 x 24 x 365 x 0.25
= $2683/year

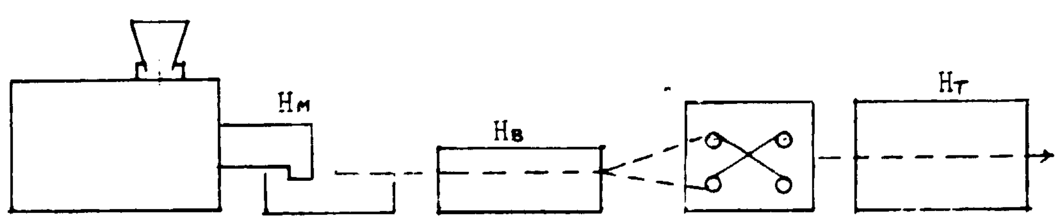
where 0.42 : loss in kW of existing capacitor
0.175 : loss in kW of capacitor according to JIS C 4902
24 : working hours /day
365 : working days /year
0.25 : cost of electricity /kWh

8.2 Electrical loads

Accoding to the company's last annual report the total electrical energy comsumption per year is 3 millions kWh/year and distributed to the extruding section (33 %), Twisting machines (25 %) and the remainder roping and other machines.

8.2.1 Extruders

The block diagram of the extruding processes is as shown below with the power consumption of each process tabulated in table 8.1.



Block diagram of extruding processes

Extruder No	No of Similar units (A)	Rating (kW)		Power consumed (kW)					Actual power consumption (B) kW	Total power (AxB) kW
		Motors	Heaters	Motors	Heaters			Total Heater		
					H_M	H_B	H_T			
E1	8	11	28	6	6	7	-	13	19	152
E10	4	37	72	19	18	16	-	34	53	212
E13	2	31	56	16	16	16	13	45	61	122
Total	14	-	-	-	152	152	26	330	-	486

Table 8.1 Power consumptions of extruders

From the table it is shown two third of the electrical energy that is required by the extruding process is used by the various heaters and the remainding one third by the extruding motors, and the spinning processes of the extruders. It was also observed that the hot baths used at the extruders are not properly lagged and that steam from the hot baths escaped freely. Therefore it is recommended that the following measures to be taken to reduce energy consumption of the extruding machines;

(1) To lag the extruding machines and the baths.

(2) Cover the bath and monitor the temperature so that the heaters are cut off at about 95 °C.

(3) Preferably the heaters for the bath of the spinning process should be replaced by steam or fuel heating.

If steam or combustion heaters are used for the hot bath, then the following cost of energy can be saved;

Existing Electrical system

Electricity cost /year

= 152 x 0.5 x 24 x 296 x 0.25 = $134,976/year

where	152	: actual rating in kW of baths heaters
	0.5	: diversity factor
	24	: working hours/day
	296	: working days /year
	0.25	: electricity cost /kWh

Alternative system

Fuel cost /year

= 152 x 0.5 x 860 ÷10000 x 0.47 x24 x 296

= $21,823 /year

where	860	: conversion factor kcal /kW
	10000	: heat content of fuel kcal /litre
	0.47	: cost /litre of fuel

Saving

saving /year = $134,976 - $21,823 = $113,153 /year

It is also observed that the recommendations as stated above will reduce the power factor of the equipments in the factor and that capacitors should be installed to contract these charges. On the other hand since water evaporation is suppressed water requirement of the factory can be reduced.

8.2.2 Twisting and Roping

This section has 13 machines of various capacities. The loading conditions for these machines are shown in table 8.2 below.

Section	Rating Capacity (kW)	No. of units of similar size	Average Power consumed (kW)	Measured voltage (V)	Power Factor
Twisting section	12	3	4.9	435	0.56
	15	7	7.9	435	0.68
Roping section	19	1	9	442	0.53
	16	2	8.2	440	0.65

Note : (1) Combined rating of Twisting machines is 141 kW and average load factor is 0.5.

(2) Combined rating of Roping machines is 51 kW and average load factor is 0.34.

Table 8.2 Loading conditions of twisting and roping machines

It was found that the motors are under utilized by as much as 50 % of capacities and operating at low power factor. Therefore we recommend that the factory conduct a through investgation of loading requirement for each machine and replaced those which has load factor less than 0.6 with those commensurate with the load requirement. Further we suggest that individual capacitor be installed in the machine to improve power factor and reduce losses.

8.2.3 Lightings

In the roshel machine section the lighting intensity is very low (within 30 - 60 lux). -It is recommended extra lightings be installed improve the luminosity 200 lux.

9 Summary

9.1 Thermal Part

It seems that the management on the energy , fuel and electricity, consumption should be considered a little bit more in order to reduce the expence on purchasing energy. Therefore in this factory, the considerable cost down on energy would be expected.

As a reference, for example, since the hot bathes in extruders have been utilized the electric resistance heatersto heat up water only to 100 °C, it is recommended that this systems should be substituted to a alternative energy source, that is, steam or direct fuel combustion.

According to this survays, the substitution to steam would be possible because the boilers have the steam generating capacity which might be enough or the required heat for the extrude operations as well as the existing facilities consuming steam, the dyeing and stretching machines.

(1) 1st. Phase Measures (no or a little investment)

		Annually fuel saving	
			$
(a) O_2 content control in flue gas to reduce to 5%	about	10	6,700 - 8,300
(b) Management of blow-down procedure	Max.	1	-
(c) Lowering of steam pressure as possible		-	-

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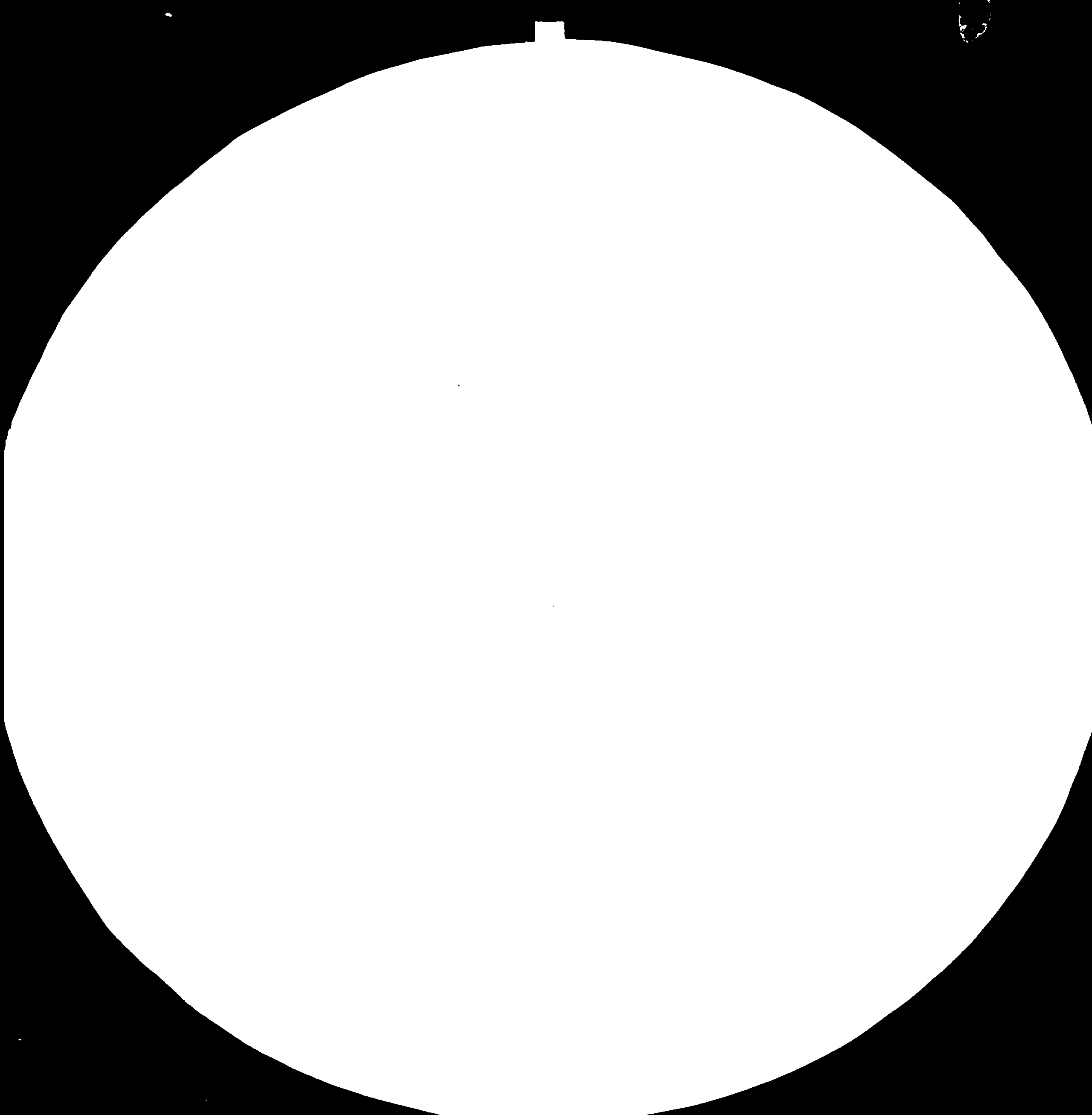
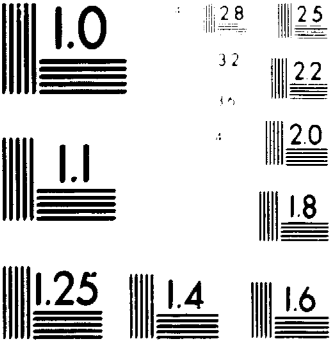




MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS
STANDARD REFERENCE MATERIAL 1010a
ANSI and ISO TEST CHART No. 2

	Annually fuel saving	
	%	$
(d) Continuous boiler opr-ration	-	-
(2) 2nd. Phase Measures		
(a) Installation of partition barrier in stretch. mach.	-	-
(b) Additional insuration of steam piping systems	-	-

9.2 Electrical parts

A major electrical recommendations for this factory where substantial saving can be realized are shown in section 8.1.3 and 8.2.1. In 8.1.3 replacing the power factor correction capacitors is recommended. An alternative energy source for the bath heaters is recommended in section 8.2.1.

KIMA SDN. BHD.

1. Outline of the Factory

Address: Sungai Chua, Kajang, Serangor, Malaysia

Capital: 4,000,000 Malaysian dollars

Type of industry: Textile

Major products: Cotton textiles

Annual output: White cloth, 400,000 m.

No. of employees: 558

Annual energy consumption:

- Electric power, 5,484,400 kWh
- Fuel, fuel oil 958 kℓ
  Kerosene 98 kℓ
  LPG 9 t

Interviewees: Mr. Hamid Ibrahim, Chief Production Manager
Mr. Heu Foot Lin, Manager of Engineering Dept.

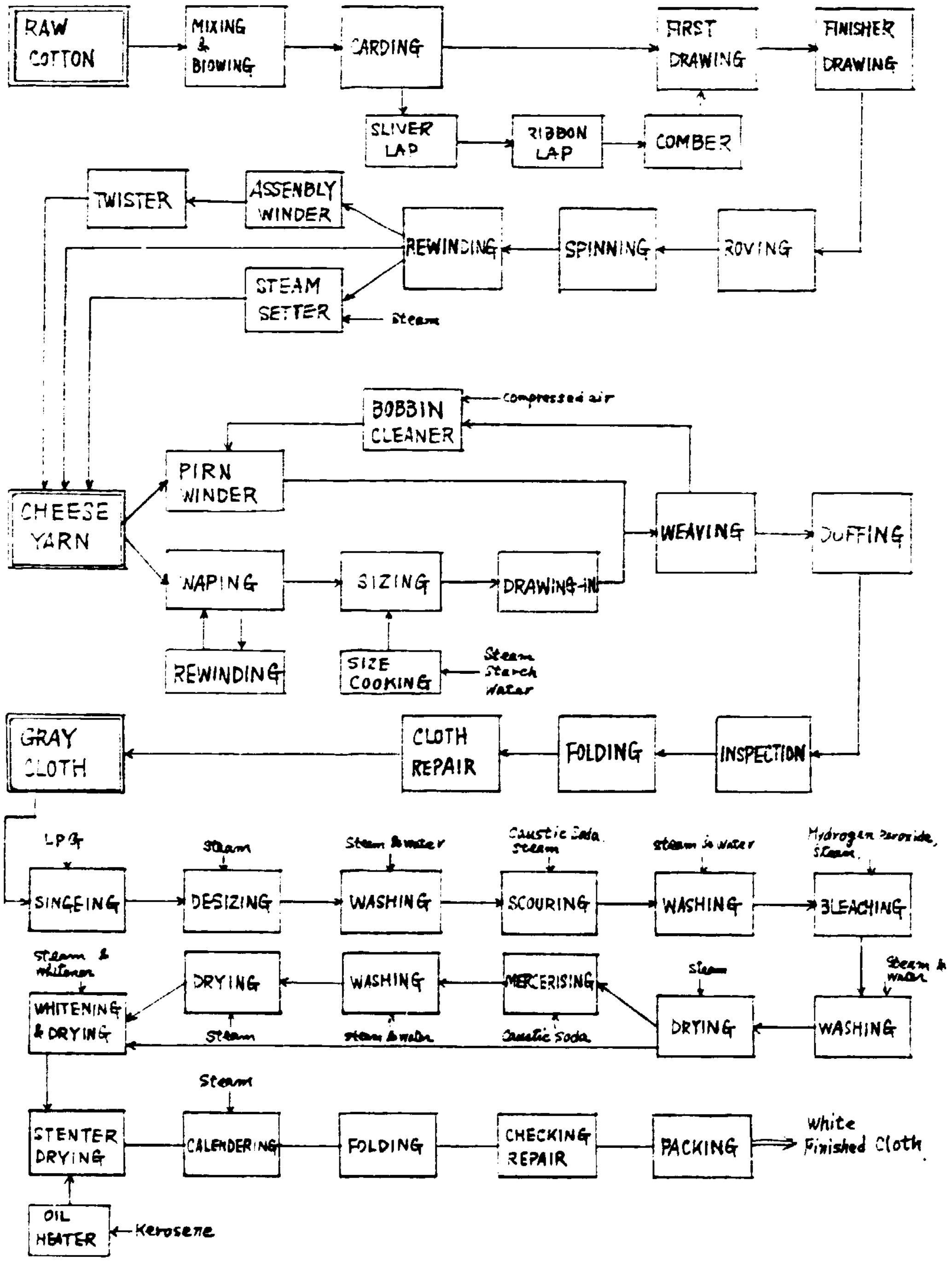
Date of diagnosis: Apr. 11 - 12, 1983

Diagnosers: Mr. M. Eguchi, Mr. R. Takahashi, and Mr. T. Sugimoto

Counterparts: Dr. Mohd Ariff Araff, Dr. Ong Peng Su, and Mr. Arizan Ab. Manan

- The factory is located in Sungai Chua which is about 25 km south of Kuala Lumpur. The production began in 1971.
- The planning of the factory was undertaken by Unitika, a leading Japanese textile company. The factory has a rationally laid-out integrated production facility to produce white cloth from cotton.
- Some of the workers received technical training in Japan. And the company received Unitika's technical guidance up to 1978.
- Power and fuel consumption and other operations are recorded in detail, and data are kept in good order. The company maintains a higher level of energy management as compared with other companies.
- The company is the only manufacturer of cotton white cloth for batik in Malaysia. But, under the influence of the global economic recession, the operations are at a level lower than 50% of the plant capacity. But, this company belongs to Mara, a large industrial group. And, all the products are delivered to Mara. No marketing efforts are necessary despite business recession. So, the company has no sales department.

2. Manufacturing Process

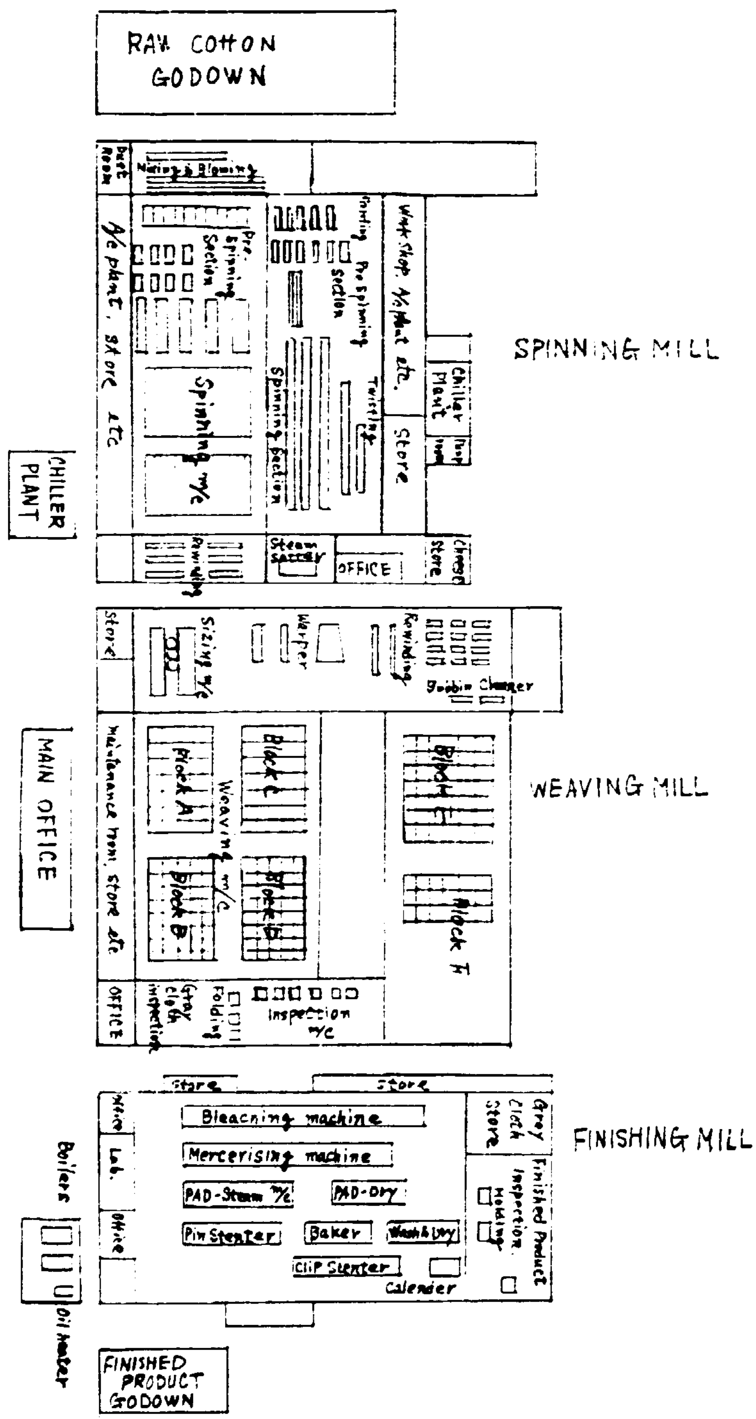


3. Major Equipment

3.1 Major Equipment

Name	No. of Units Installed	Type, etc.
Boilers	2	Cochran boiler Flue tube type Rated evaporation: 7 t/h Rated steam press.: 10.55 kg/cm^2 Kind of energy used: Fuel oil
Oil heater	1	Store Vapor Liquid Phase Heater Products: 200°C heated oil Kind of energy used: Kerosene
Spinning machines	41	Products: Spun yarn Nominal output: 90 t/M Kind of energy used: Electricity
York centrifugal chillers	2	Products: Chilled water (7°C) Nominal output: 3,600 ℓ/min at 7°C and 400 ℓ/min at 20°C Kind of energy used: Electricity
Weaving looms	520	Products: Grey cloth Nominal output: 850,000 m Kind of energy used: Electricity

3.2 Layout


RAW COTTON GODOWN
SPINNING MILL
CHILLER PLANT
Spinning m/c
Store
OFFICE
WEAVING MILL
MAIN OFFICE
Sizing m/c
Warper
Rewinding
Block A
Block B
Block C
Block D
Block E
Block F
Weaving m/c
Inspection m/c
OFFICE
FINISHING MILL
Bleaching machine
Mercerising machine
PAD-Steam m/c
PAD-Dry
Pin Stenter
Baker
Wash & Dry
Clip Stenter
Calender
Lab.
Boilers
Oil heater
Grey cloth Store
Finished Product Inspection
FINISHED PRODUCT GODOWN

4. Situation of Energy Management

- The production committee meetings are held twice a month. Energy problems are discussed whenever necessary.
- Training programs are only directed to staff members. There is no training program directed to general workers. But, the factory manager conducts an energy-conservation campaign to workers.
- Daily recording is done on power and fuel consumption with respect to the major equipment, and data are kept in good order. Whenever we asked for data, they were quickly produced.
- Energy cost accounting is done monthly. Data analysis for energy consumption rate or a control chart, or variable factors analysis is not apparently done.
- Ambient temperatures and humidities are measured every two hours at several points in the airconditioned spinning mill, and the results are immediately shown on a graph. This was the only factory in Malaysia where such activities were observed during our surveys. This is extremely useful in enhancing the workers' consciousness.

5 Situation of Fuel Consumption

The two boilers with completely same capacity of 7 tonne of steam/hr is consuming the fuel oil at the rate of 958 kl. annually.

A heat transfer solvent furnace has the kerocene consumption of 98 kl. annually, while the desizing machine in the breaching range of finishing lines for product has LPG consumption rate of 9 tonne annually.

According to the factory manager, 90 % of the fuel oil purchased on factory has been converted to steam and 90 % of its steam has been utilized for finishing lines of the white cotton cloth.

5.1 Boiler Operation

Actually in this factory the daily amount of fuel consumption is recorded in summerizing togather of two boilers. Fortunately overhal of No. 2 boiler was undertaken before one month and only No. 1 boiler was operated. therefore from the record for such period of single operation the rate of fuel consumpion for single boiler was available.

5.1.1 No. 1 Boiler

(1) Operating and Measured Data

A) Fuel oil specification

(a)	Specific gravity	0.957
(b)	Gross calorific value	43.0 MJ/kg

or 10,272.0 kcal/kg

(c) Compositin (by wt.) C ; 85 %

H ; 12 %

S ; 3 %

(d) Unit price 0.5138 $/litre

(e) Fuel consumption per boiler 232 litre/hr

B) Flue gas condition

(a) O_2 content 10.5 %

(b) Temperature 220 °C

C) Blow-down procedure

(a) Period once/4 hours

(b) Mark of water level meter 1/2 inch

(c) Approximate discharged volume 100 litre

(2) Heat Balance on No. 1 Boiler Operation

Using above data, the heat balance is calcurated in terms of per kg of fuel as belows ;

Description	Input		Output	
	Kcal/kgfuel	%	kcal/kgfuel	%
Input Fuel	9,624.0	100.0		
Output Flue gas heat loss			1,384.0	14.4
Dispersion heat loss			102.0	1.1
Blow-down heat loss			16.0	0.1
Generated steam (from balance)			8,122.0	84.4
Total	9,624.0	100.0	9,624.0	100.0

Table I.5.1 Heat Balance of No. 1Boiler

5.1.2 No. 2 Boiler

This boiler was overhauled only before about one month according to the periodical maintenance. Then the performance of the boiler would provide the useful information on the effects due to the cleaning of the outside surface of the boiler tubes.

(1) Operating and Measured data

Almost of all data of No. 2 boiler are same as No. 1 except the flue gas conditions.

A) Flue gas condition.

(a) O_2 content — 5.1 %

(b) Temperature — 198 °C

(2) Heat Balance on No. 2 Boiler Operation

Using above data, the heat balance is calcurated in terms of per kg of fuel as belows ;

Description	Input		Output	
	kcal/kgfuel	%	kcal/kgfuel	%
Input				
Fuel	9,624.0	100.0		
Output				
Flue gas heat loss			814.0	8.5
Dispersion heat loss			102.0	1.1
Blow-down heat loss			16.0	.1
Generated steam (from balance)			8,692.0	90.3
Total	9,624.0	100.0	9,624.0	100.0

Table I.5.2 Heat Balance of No. 2 Boiler

5.2 Bleaching Range in Finishing Line

The straight and smooth steam piping lines are suitably insulated except in areas which are located near to the boilers and the steam consuming facilities.
the roughly estimated amount of dispersion heat from indivisual steam consuming machines in the breaching range is as follows ;

Description x Units Nos.	Temp.	Bared Surf Area	Piping		Dispers. Heat	Dispers. after Insulation	Recov. Heat
			Pipe	Fitt.			
	°C	m^2	"xm	"xpcs	kcal/hr	kcal/hr	kcal/hr
1. Dry Cylinder			2x2	V 2x1	840	133	707*
2. Washer x 1	100	Free 0.34 Case 9.23	2x1	V 2x1	10,886 600	3,110 95	7,776 505*
3. Desize Saturator	80	Case 34.6	2x9	V 2x1	17,300 2,520	6,920 399	10,380 2,121*
4. Washer x 3	100	Same as 2	2x1	V 2x1	32,658 1,800	9,331 285	25,127 1,515*
5. Caustic Saturator x 1	100	Same as 2	1x1	V 1x1	10,886 350	3,110 50	7,776 300*
6. Vaporloc x 1	130	31.6	2x2	V 2x4 F 2x2	31,620 1,920	6,324 304	25,296 1,616*
7. Washer x 3	100	Same as 2	2x3 1x3	V 2x6 F 1x3	34,458 2,880 8 840	9,845 456 126	24,613 2,424* 714*

Description x Unit Nos	Temp.	Bared Surf. Area	Piping		Dispers. Heat	Dispers. after Insulation	Recov. Heat
			pipe	Fitt.			
8. Peroxide Saturat.	Room Temp.						
9. Vaporloc x 1	115	31.6	2x2	V 2x4	37,944	8,928	29,016
				F 2x2	2,160	342	1,818*
10. Washer x 3	100	same as 2	2x1.5	F 2x2	44,458	9,845	24,613
					1,800	285	1,515*
11. Drying Rolls x 16			2x12 1x8	V 2x2	4,720	734	3,982*

Summary on Recovery of Heat

Intensive Insulation on Cace 154,597 kcal/hr

Intensive Insulation on Piping 17,217 kcal/hr

Total 171,814 kcal/hr

as steam 312 kg/hr

Notes 1) Line of * mark is the value on piping.

2) Heat loss after insulation on next column of last is calculated as follows ;

a) Due to intensive insulation on cases,

b) Assuming that the surface temp. decrease to 50 °C,

Initial heat loss x $(T_i - T_o)/(T_a - T_o)$ where T_i, and T_a are temp. of surface before and after insulation respectively and T_o is temp. of ambient.

Table I.5.3 Dispersion Heat Loss in Bleaching Range

6 Problems in Thermal Energy Utilization and their Potential Solutions

Two boilers in this factory have been performed relatively well, espetially No. 2 boiler, although some degree of excessive chemical dosing might have occured. Actually according to the observing the blow-down water the boiler water in vessel are presumed to be brownish in colour.

Comparing to the boiler performance, the management on steam consumption is not enough.

6.1 Boiler Operation

6.1.1 O_2 Content in Flue Gas

No.2 boiler, which had just been overhauled, the flue gas condition of 5.1 % O_2 content and temperature below 200 °C. This flue gas condition which is very close to recommended values in Japan, could be achieved primarily due to the descaling of the heat transfer boiler tubes during the periodical overhaul. If No. 1 boiler underwent similar overhaul, the fuel consumption would be improved by 6 % comparing to before overhaul.

This improvement is equivalent to about $2,000/month or $33,600/year of fuel savings. therefore it is recommendable that No.1 boiler should undergo the overhaul as soon as possible.

6.2 Steam Consumption Facilities

6.2.1 Extensive Insulation of Steam Piping Lines

If extensive insulations were carried out on steam piping lines close to the facilities, with reference to the table of the dispersion heat loss in the bleaching range shown in Table I.5.3, the estimated amount of fuel saving would come to about 17,000 kcal/hr which corresponds to 10 kl/year or $5,400/year.

6.2.2 <u>Extensive Insulation on Surface of Equipment in Bleaching Range</u>

The existing surface temperature of the steam consuming equipments in the bleaching range is about 100 °C If proper insulation is applied on the equipment surface, and the temperature would be able to be lowered to 50 °C,

This measures would give 150,000 kcal/hr as shown in Table I.5.3. This value is equivalent to 92 kl/year or about $50,000/year.

6.2.3 <u>Similar Measure on Other Range in Finishing Line</u>

These equipment such as mercering range should be similarly insulated to achieve further savings in fuel consumption.

7. Electricity

7.1 Electrical consumption characteristics

- supplier	: National Electricity Board of the States of Malaya
- contractual maximum demand	: 950 kW
- average monthly consumption	: 302.5 x 10 kWh
- average factory load factor	: 0.36
- contractual power factor	: 0.91
- rated supply voltage	: 11000 Volts
- transformer capacity	: 2 x 1500 kVA 2 x 800 kVA 2 x 750 kVA

7.2 Schematic diagram and outline of factory

Electrical schematic diagram is as shown in Figure 7.1. This factory is widely spread and has a lot of equipments installed utilizing both electricity and steam. The factory recieved 11kV supply and has six step down transformers installed with total capacity of 6100 kVA. The major electrical loads are air conditioners and large number of small motors with total installed capacity of 2000 kW. This transformers are very lightly loaded and 25 % of the load is utilized by air conditioning equipments.

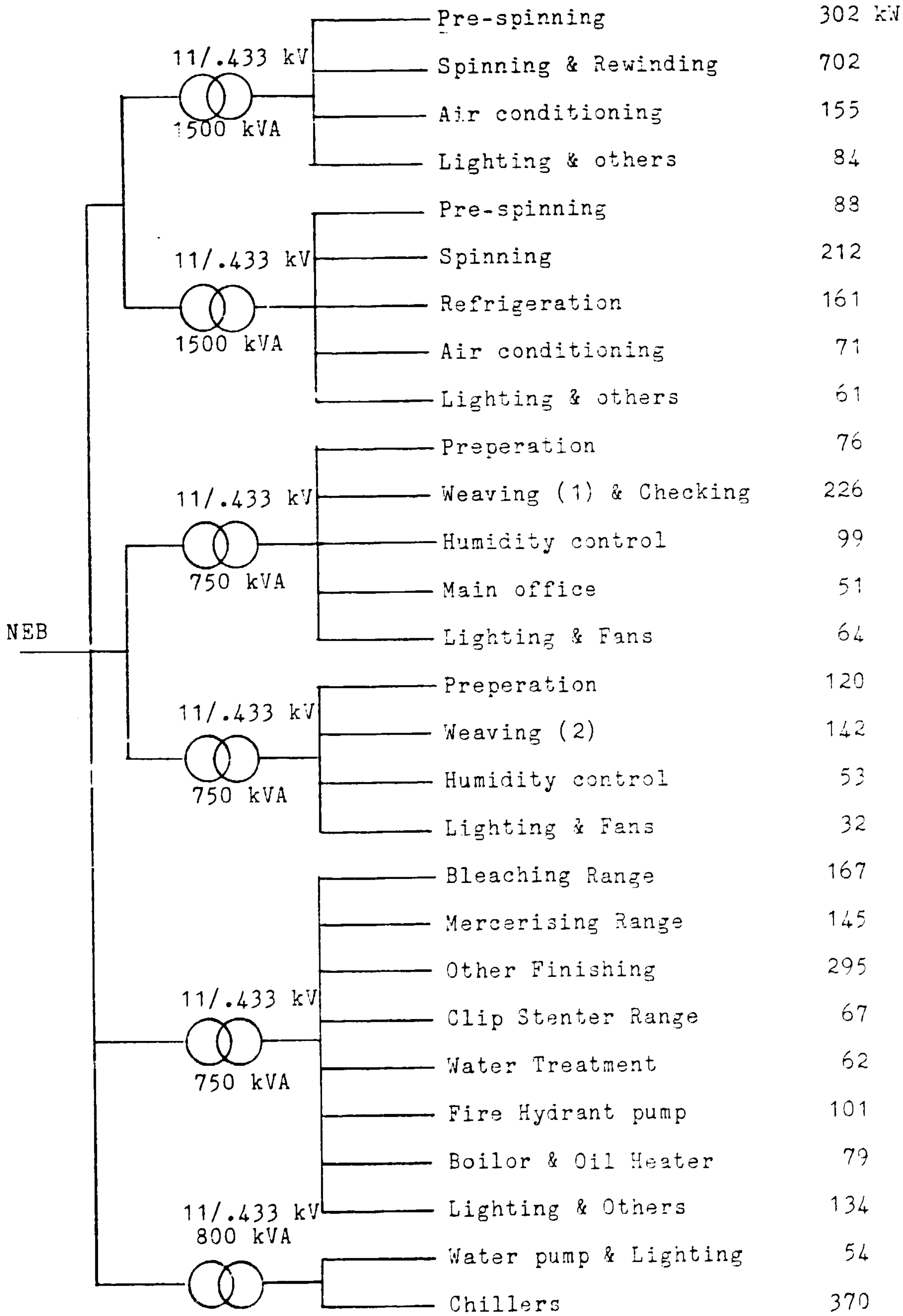


Figure 7.1 Electrical schematic diagram of KIMA SDN. BHD.

8. Problems in electric power utilization and their potential solutions

8.1 Source

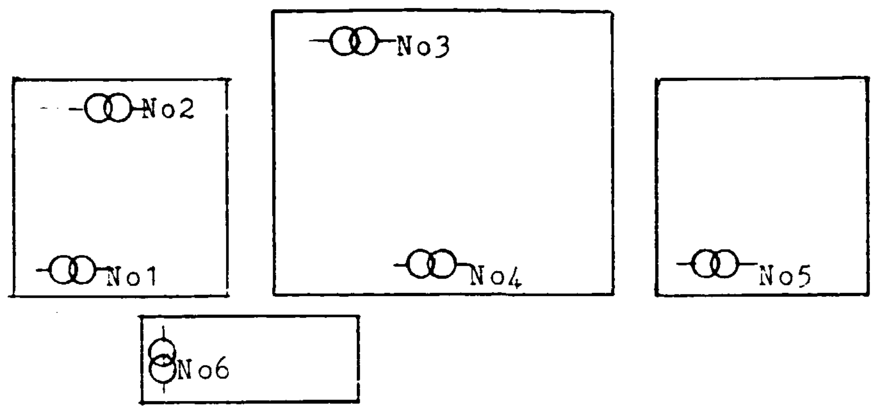
8.1.1 Transformers

As mentioned earlier the factory has total installed transformer capacity of 6100 kVA against total load of 1934 kW (2125 kVA assuming 0.9 p.f) and the load is distributed every through out the six transformers. The load conditions for the various transformers are indicated below in table 8.1.

Transformer No	Rating (kVA)	Actual load connected (kW)	Measured data: Voltage (V)	Measured data: Power consumed (kW)	Measured data: Power factor	Load factor
1	1500	1243	417	607	0.89	0.45
2	1500	593	431	315	0.86	0.24
3	750	515	410	405	0.94	0.57
4	800	347	424	209	0.96	0.27
5	750	1050	423	185	0.90	0.27
6	800	424	430	213	0.93	0.29
Total	6100	4172	-	1934	0.91	0.35

Table 8.1 Load conditions of transformers

The outline of the factory against the location of the transformers is as shown in the Figure below



Outline of factory against transformer locations

Since the transformers are lightly loaded it is recommended that only three transformers (i.e Nos. 1, 3 and 5) to be used for all the loads with total installed transformer capacity of 3050 kVA and the remainder to be placed on stand by but not switched on. It is also recommended that the low voltage switch board connected to each transformer be interlinked to provide flexibility of supply. If such measure is implemented the saving in energy is as follows;

$$\text{saving/year} = \{1500\ (1-0.988) + (750 + 800)\times(1-0.986)\} \times 0.2 \times 24 \times 365 \times 0.17$$

$$= \$11{,}324\ /\text{year}$$

where

0.988	:	efficiency of 1500 kVA transformer
0.986	:	efficiency of 800 kVA or 750 kVA transformer
0.2	:	iron loss factor
24	:	working hours /day
365	:	working days /year
0.17	:	cost of electricity /KWh

8.1.2 Voltage

From the name plates of the motors, they are rated from 400 volts to 415 volts but the actual supply voltage measured varies from 410 volts to 430 volts. It is recommended that voltage to the factory be standardized at 415 volts for all equipments. This exercise will improve power factor and expected to save energy cost as follows;

$$\text{saving /year} = 1934 \left(\frac{1}{0.81} - \frac{1}{0.812} \right) \times 16 \times 298 \times 0.17$$
$$= \$4782 \text{ /year}$$

where 1934 : actual power in kW cosumed by all the motors.

0.81 : efficiency of typical 1.5 kW motor at voltage of 430 volts.

0.812 : efficiency of typical 1.5 kW motor at 415 volts.

16 : working hours /day

298 : working days /year

0.17 : cost of electricity /kWh

8.1.3 Power factor

The factory has automatic power factor correcting equipments installed for each transformer such that power factor of input supply is good (0.91). However some of the capacitors are operating at temprature above 70 °C. Power input into these capacitors are also considered high, about 420 watts each (see report or FUSAN FISHING NET BHD). Therefore it is recommended to replace the capacitors with those that consume less power (less than 175 watts for a typical 50 kVAr capacitor) and suitably ventilated.

8.2 Electric power consuming management

These factory has contractual maximum demand of 950 kW. During our visit the factory was not in full production. Therefore it is not possible for us to recommend the new contractual maximum demand value. It is recommended that the factory make a study on the maximum demand required during full production operation and re-evaluate the value of contractual maximum demand. If the factory maximum demand is lower than the contractual demand, a renegotiation with the supplier on a new contractual maximum demand value should be carried out.

It is also suggested that the factory install a total consumed power indicator and alarm to prevent the factory operating beyond the contractual maximum demand.

8.3 Electrical loads

8.3.1 Air conditioning

This factory has two central air conditioning system installed to control air humidity and temperature in factory spaces of approximately 25000 square meters. Unfortunately many section of the factory are not utilized but are still air conditioned. (e.g. one third of spinning area are not utilized). It is suggested that for those area which are not utilized be sectionalized from the operating area with suitable temporary curtains or sheetings (vinyl) to prevent unnecessary wastage in the air conditioning system. Further saving in air conditioning system can also be realized by relocating the air compressors, sizing machines outside the air conditioned room and introduce special curtain to reduce free mixing of air at the many doors. Assuming that one third of the spinning room is compartmentalized a saving of $22696 / year can be realized as shown by the culculation below;

Calculation

(1) Total power taken by refrigeration plant

= 213 kW

(2) Total capacity of blower for air conditioning plant = 503 kW

(3) Total capacity of blower for the spinning room only = 59 kW

Therefore proportional power required to air condition the spinning room

$$= (\ 213 \times \frac{59}{503} + 59\ )\ \text{kW} = 84\ \text{kW}$$

If one third of the room is cmpartmentalized the energy save

$$= 84 \times \frac{1}{3} = 28\ \text{kW}$$

Therefore saving/year = 28 x 16 x 298 x 0.17

= $22,696/year

where 16 : working hours/day

296 : working days/year

0.17 : cost of electricity/kWh

8.3.2 Motors

Our measurements indicate that the motors in the spinning section have very low load factor (only 0.25). Therefore it is recommended that the factory carry out a through study on the load requirements of these motors and steps should be taken to replace those motors having load factor less than 0.6 with those commensurate with the load requirements. This measure will certainly improve the power factor and thus increase the motor efficiency

In the weaving section however most of the motors are fully loaded and some condition of over load were registered. It is generally accepted that this condition is safe and good provide the maximum motor temperature rise is not exceeded.

8.3.3 Lightings

Overall factory lighting is reasonably good as shown in table 8.2 below.

Section of the factory	lighting intensity (lux)
Spinning	105 - 256
Rewinding	140
Weaving	35 - 164
Finishing	360 - 650

Table 8.2 Factory lighting intensity

From the table the lightings in the three sections of the factory , i. e spinning, rewinding and weaving sections are below the comfortable level. According to JIS standard a factory of this nature requires lighting intensity of 250 lux to 300 lux. Therefore it is recommended that the lighting fittings of these sections to be lowered by one meter to achieve the required intensity. The example below shows that by lowering the lighting fittings from 5 meters to 4 meters an improvement of lighting intensity from 150 lux to 234 lux can be achieved. For areas with luminousity below 100 lux extra lighting fitting are necessary.

<u>example</u>

new intensity $= 150 \times \left(\frac{5}{4}\right)^2 = 234$ lux.

9 Summary

9.1 Thermal Part

The boilers have been performed considerablly well. On other side, the management on steam consumption in the finishing lines have not been enough.

(1) 1st. Phase Measures (no or a little investiment)

	Annually fuel saving %	Annually fuel saving $
(a) To overhaul No. 1 boiler as a periodical maint'ce	6	33,600

(2) 2nd. Phase Measures (some investment)

(a) To insulate the steam piping systems	about	5,400
(b) To insulate the case of equipments in bleaching range	about	50,000

9.2 Electrical parts

For this factory there are several avenues for energy saving measures to implemented. The following recommendations have been made;

(1) Reduction of transformer capacity, saves $11,324/year.

(2) Reduction of supply voltage to 415 volts, saves $4,732/year

(3) Reduction of contractual maximum demand and installation maximum demand alarm indicator (see section 8.2)

(4) Partitioning of the spinning section to reduce air-conditioning load, saves $22,696/year.

Energy Conservation Survey
省エネルギー調査表

1 Name of Factory
工 場 名 ______

2 Location
所 在 地 ______ Tel. ______

3 Name of Company Officials
会社役員名

President
社 長 ______

Factory Manager
工 場 長 ______

Energy Manager
エネルギー担当者 ______

4 Segment of Industry
業 種 ______

5 Capital
資 本 金 ______ M$

6 Annual Turnover
年間売上高 ______ M$

7 Number of Employees
従業員数 ______

8 Number of Engineers
技術者数 ______

Electricity
電 気 ______

Heat
熱 ______

9 Major Products
主要生産物 ______

______

10 Production Capacity of Major Products
主要生産物の生産能力

Nominal
公 称 ______

Present Condition
現 状 ______

11 Fuel Consumption 燃料消費高

☐ Fuel oil 重油	kl/y	M$/y
☐ Diesel oil 軽油	kl/y	M$/y
☐ Kerosene 灯油	kl/y	M$/y
☐ Gasoline ガソリン	kl/y	M$/y
☐ LPG 液化石油ガス	t/y	M$/y
☐ Natural gas 天然ガス	m³/y	M$/y
☐ Lignite or Brown Coal 亜炭又は褐炭	t/y	M$/y
☐ Bagasse バガス	t(m³)/y	M$/y
☐ Charcoal 木炭	t/y	M$/y
☐ Firewood 薪	t(m³)/y	M$/y
☐ Others その他 ( )	/y	M$/y

12 Electric Power, 電力

Electricity Consumption 電力消費高	KWh/y		M$/y
Contract Demand 契約電力	KW.	Receiving Voltage 受電電圧	V.
Power Factor 力率	%		
Power Plant 発電設備	Have or Not.	Capacity 能力	KW or KVA.

13 Water Consumption, 水消費量

Sea Water 海水	m³ or t/y	River Water 河水	m³ or t/y
Underground Water 地下水	m³ or t/y	City Water 水道水	m³ or t/y

14 Boiler, ボイラ

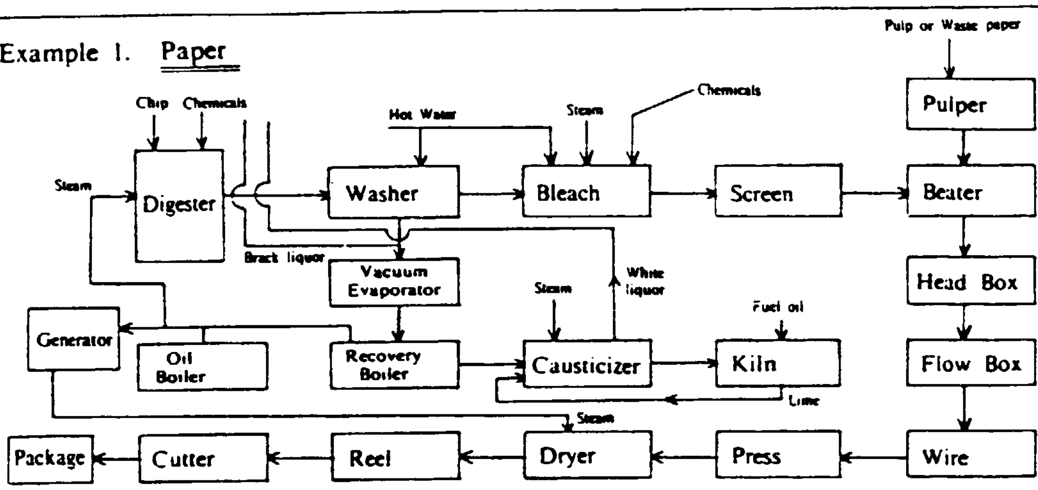
Built(A.D.) 設置(西暦)	Type 型式	Nominal Capacity 公称能力		Kind of Fuel 燃料の種類	Operating period 運転時間	
		Steam Press. kg/cm²G	Evaporating Volume t/h		hrs/day	days/y

15 Major Facilities Using Energy, エネルギー使用の主要設備

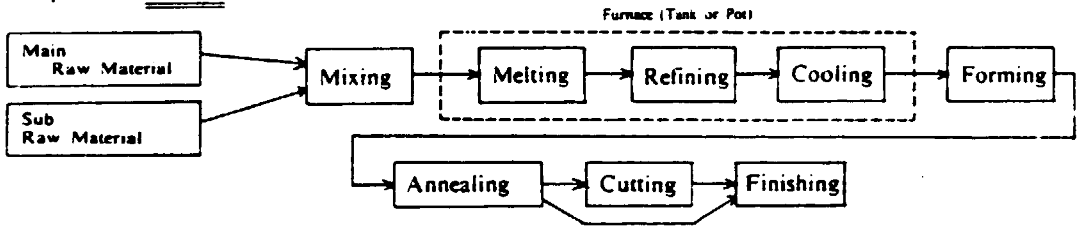
Built(A.D.) 設置(西暦)	Name of Facility 設備名	Products 生産物	Output 生産高		Kind of Energy used 使用エネルギーの種類	Operating period 運転時間	
			Nominal 公称	Present Condition 現状		hrs/day	days/y

16 Flow-chart of Producing Process of Major Products, 主要生産物の生産工程図

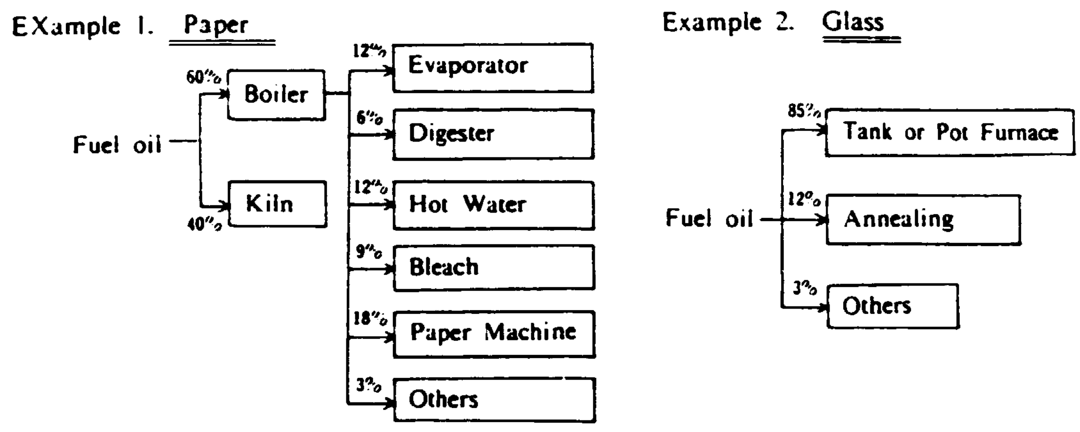
Example 1. Paper



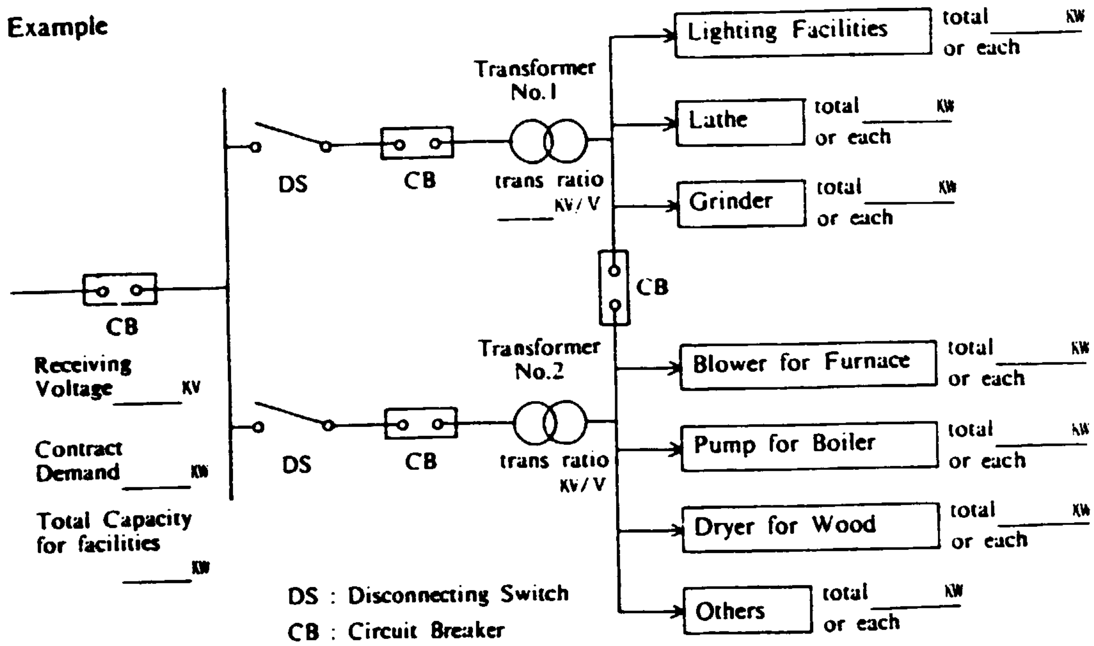
Example 2. Glass



17 Energy Flow-chart, エネルギー流れ図



18 Skeleton Diagram, 単線結線図



DS : Disconnecting Switch
CB : Circuit Breaker

19 Plant Layout, 工場配置図

20 In case you have any problem(s) in your course of promotion of energy conservation, please circle the no(s). of applicable item(s) among the following: (Maximum 5 items)

省エネルギー推進上の問題点があれば，下記の該当する項目に丸印を付して下さい。(但し，最高5項目まで)

(1) Prospect of energy price is not clear.
エネルギー価格の見通しが不明。

(2) The proportion of energy cost in the whole cost of enterprise is small.
企業におけるエネルギー費用の割合が小さい。

(3) Increase of energy cost can be covered by raising the prices of products.
エネルギー費用の上昇は製品値上げでカバーできる。

(4) Instability of energy supply. (power stoppage, etc.)
エネルギー供給が不安定（停電など）。

(5) Shortage of engineers.
技術者が不足。

(6) Difficulty in obtaining good energy conservation equipments.
省エネルギー機器のよいものが手に入り難い。

(7) Information such as active cases is not easy to obtain.
実施例のような情報が入りにくい。

(8) System of research and development is not sufficient.
研究開発体制が不十分。

(9) Shortage of fund for facility improvement.
設備改善の資金が不足。

(10) The facilities are superannuated.
設備が老朽化している。

(11) Employees' consciousness is low.
従業員の意識が低い。

(12) No personnel is available who can educate the employees.
従業員教育をできる人がいない。

(13) Shortage of measuring equipments.
計量設備が不足している。

(14) No time to analyze energy consumption rate.
原単位解析を行う時間がない。

(15) Shortage of information on government's measures.
政府施策の情報が不足。

(16) Shortage of government's subsidiary measures.
政府の助成策が不足。

(17) Others
その他。

1 Energy Management (エネルギー管理)

1	Company's Energy Conservation Policy	企業の省エネルギー方針		
	Setting up Target	目標設定	Set up　　not set up	
	Numerical Value of Target	目標値	______ % improve to ____________ base	
	Completion Deadline	達成期限	by ________	
	Investment for Energy Conservation	省エネルギー投資		
	Investment Scale	投資額	1981 ________ Bts 1982 ________ Bts 1983 Plan ________ Bts	
	Judgement for Investment	投資基準	Pay Back Time, within ________ Yrs	
2	Check on Energy Consumption	エネルギー消費量管理		
	Measurement of Consumption	消費量計測	Electric Power	Fuel
			Times/	Times/
	Factory Total	工場計	done　not done	done　not done
	By Major Process	主要工程別	done　not done	done　not done
	By Major Facility	主要設備別	done　not done	done　not done
	Data Analysis	データ解析		
	Grasp of Energy Consumpt's. rate	原単位把握	done　not done	
	Preparation of Control Chart	管理図作成	done　not done	
	Analysis of Variance	変動要因分析	done　not done	
	Cost Control	原価管理		
	Energy Cost Accounting	エネルギー原価計算	Monthly,　Times/y,　not done	
	Energy Cost Distribution by Process	工程別配分	done　not done	
	Accounting of Heat Balance	熱勘定	done　not done	

Diagnoser	

Date		Factory	

3	Organization	組　　織			
	Planning and Promotion	企画・推進	Section		Person in Charge
	Committee	委 員 会	held		not held
	Frequency of Holding	開催頻度	________	Times/y	
	Committee Chairman	委 員 長	________		
	Project Team	プロジェクトチーム	made		not made
	Consultant Contract	コンサルタント契約	made		not made
4	System	制　　度			
	Improvement Proposition System	改善提案制度	is		isn't
	Achievement Commendation System	実績表彰制度	is		isn't
	Inspection, Audit	視察，診断	done		not done
5	Education of Employees	従業員教育			
	Seminar	研 修 会	held	Times/y	not held
	Observation Meeting	見 学 会	held	Times/y	not held
6	Campaign to Employees	従業員への呼びかけ			
	Appeal from Factory Manager	工場長の呼びかけ	done		not done
	Poster, etc.	ポスター　等	done		not done
7	Activities in the Business Circles	業界の活動	Practised		not practised

2. Heat

2-1 Furnace, Kiln, Dryer

1	Part	工　程				
2	Name of Equipment	設備名				
3	Use	用　途				
4	Charge	被加熱物				
5	No. of Furnace	番　号				
6	Type	型　式				
7	Maker	メーカー				
8	Time built	設置時期				
9	Outer Dimension Length or Dia. Width Height	外法寸法 長さ・径 巾 高				
10	Design Capacity	設備能力				
11	Usage Continuous Batch h/Day h/month	使用状況 連　続 非連続				
12	Induced Draft Fan Forced Draft Fan	吸込み送風機 押込み送風機	___m^3/h ___mmAq ___kW ___ ___ ___			
13	Improvement done	改造実績				

Diagnoser	

Date		Factory	

14	Fuel Name Lower Heating Value Specific Gravity Moisture	燃料 名前 発熱量（低位） 比重 水分	 Kcal/kg. ℓ.m^3N
15	Average Consumption	燃料使用量（平均）	/h
16	Oil Storage Tank: Contents Volume Temp. Insulation	油貯蔵 タンク 油種 容量 温度 保温	 m^3 °C mm
17	Fuel Receiving Measuring Volume Temp. Sp.grav. Analysis	受入れ 計量 温度測定 比重 〃 分析	 done not done done not done done not done done not done
18	Oil Leak	油洩れ	good not good
19	Steam Pressure Temp.	スチーム 圧力 温度	 kg/cm^2G °C
20	Electricity Elect. Heater Infra Red Lamp	電力 電熱 赤外ランプ	 ________kW ________V ________kW ________V

	No. of Equipment	設備名	
21	Combustion		
	Burner	バーナー	Pressure jet, ____ Low pr.air atomizing, ____ Steam or air atomizing, ____ Rotary, ____ Intermixing, ____ Interior atomizing, ____ Semi mixing ____
	Burner Tile	バーナータイル	Good not good
	Cleaning of Burner tip	バーナー手入	times/y
	Flame Color	火焔色	good not good
	Length	長さ	good not good
	Sparks	花火	good not good
	Blow off	吹きとび	good not good
	Color of Smoke	煙の色	good not good
	Air/fuel ratio	空気比	Factory Data ____ Measured ____ $m = \frac{0.21}{0.21 - (O_2)}$
	Automatic Controller	制御装置	exist not exist
	Fuel Consumption	燃料量	____ kg.ℓ.m^3/h
	Fuel Temp.	油温	____ °C (at Burner, after Heater)
	Air Temp.	燃焼空気温度	
	Primary Air flow	一次空気量	
	Secondary Air flow	二次空気量	
	Atomizing press.	噴霧圧	

	Quantity of Burners					
Zone	Preheating		Heating		Soaking	
Burner Type	axial	Side	axial	Side	axial	Side
Upper Zone						
Lower Zone						

	No. of Equipment	設備番号	
22	Furnace Pressure	炉圧	________ mmAq (Measuring Point ________ mmH)
	Pressure Control	炉圧制御	done not done
	Movement of Damper	ダンパー作動	good not good
	Air Sucking	空気吸込	
	from Wall	炉壁	good not good
	Burner Side	バーナーまわり	good not good
	Door	出入口	good not good
	Truck	台車シール	good not good
	State of Stack, Gas duct	煙突, 煙道の状態	good not good
	Cooling Air	冷却空気	________ m^3/min.
23	Heating	加熱	
	Furnace Temp.	炉温	________ °C
	Charging Temp.	装入温度	________ °C
	Extracting Temp.	抽出温度	________ °C

	Preheating Zone	Heating Zone	Soaking Zone
Set	°C	°C	°C
Actual	°C	°C	°C

	Temp. measurement	温度測定	Thermocouple( ), Resistance Thermometer, Optical Pyrometer, Radiation thermometer, Seger cone
	Temp. Controller	温度制御装置	exist not exist
	Burner Setting	バーナー取付	good not good
	Arrangement of Charge (Furnace Load Factor)	装入方法	good not good, Truck Speed ________
	Seal		
24	Size of Charge	材料寸法	
	Heat Utilization of previous process, Hot Charge	ホットチャージ	done not done

	No. of Equipment	設備番号				
25	Drying	乾燥				
	Air Temp.	風温	________ °C			
	Air Flow	風量	________ m^3/h			
	Moisture of Charge	装入物水分				
	Inlet	入口	________ %			
	Outlet	出口	________ %			
26	Insulation	断熱	Preheating Zone	Heating Zone	Soaking Zone	
	Structure of Wall	壁面構成				
	Refractory Brick	耐火材				
	Insulating Zone	断熱材				
	Outer Wall	外壁				
	Color of Wall Surface	壁の色				
	Temp. of Wall, Surface	壁面温度				
	Side Wall	側面	°C	°C	°C	
	Roof, Crown	上面	°C	°C	°C	
	Heat Flux		$kcal/m^2h$			
	Insulation of Skid	スキッド断熱	good	not good		
	Weight Reduction of truck, conveyor, etc.	台車・コンベア等の軽量化	done	not done		

	No. of Equipment	設備番号				
27	Waste Heat Recovery	廃熱回収				
	Name of Recovery Equipment	回収設備名				
	Type	型式				
	High Temp. Fluid	高温流体				
	Low Temp. Fluid	低温流体				
	Heat Recovered	回収熱量				
	Flow	流量				
	Temp. Rising (Falling)	温度上昇(低下)				
	Specific Heat	比熱				
	Temp. of Waste gas	排ガス温度				
	Furnace Outlet	炉出口	________ °C			
	After Heat Recovery	廃熱回収後	________ °C			
	Clearing of Heating Surface	伝熱面掃除	________ Times/y			
	Preheating Zone in Furnace	炉の予熱帯	exist	not exist		
	Air Leak in Heat Recovery Equip.	廃熱回収設備の空気洩れ	found	not found		
	Cooling Water flow	冷却水量				
	Water Inlet temp.	〃 入口温度				
	Water Outlet temp.	〃 出口温度				

	No. of Equipment	設備番号		
28	Operational Management	操業管理		
	Operation Standard	作業標準	made	not made
	Heating Curve	昇温曲線	exist	not exist
	Recording	記録	good	not good
	Maintenance	保全整備	good	not good
	Period	周期	________ ly	
	Record	記録	good	not good
29	Current Performance	実績		
	Output (or Input)	処理量	________ t/h	
	Fuel Consumption	燃料量	________ ℓ.kg.m^3/h	
	Heat Efficiency	熱効率	________ %	
	Loss with Waste Gas	排ガス損失	________ Kcal/h	________ %
	Loss with Coolant	冷却水損失	________ Kcal/h	________ %
	Loss through Wall	放熱損失	________ Kcal/h	________ %

2-2 Steam Consuming Equipment (蒸気使用設備)

1	Part	工程	
2	Use	用途	
3	Name of Equipment	設備名	
4	No. of Equip.	番号	
5	Type	型式	
6	Maker	メーカー	
7	Time built	設置時期	
8	Dimension	寸法	ℓ ____ mm x w ____ mm x h ____ mm, d ____ mm x h ____ mm
9	Heating surface area	伝熱面積	m^2
10	Volume	容量	
11	Capacity	能力	
12	Subject of heating	被加熱体	
13	Heat source	熱源	Steam: kg/cm^2G, °C t/h, Hot water °C, t/h
14	Quantity of Treatment	処理量	
15	Operating condition Temp. Press.	操業条件 温度 圧力	 °C kg/cm^2G
16	Insulation Surface Temp.	断熱 表面温度	mm good, not good °C heat flux $Kcal/m^2h$

Diagnoser		Date		Factory	

17	Cleaning for heating surface	伝熱面の掃除	done　　　not done
18	Instruments	計装	Temp.　Press.　Flow.　Other:
19	Auxiliary Equip.	附属設備	
	Heat Recovery	熱回収	exist　　　not exist　　　type
	High Temp. Fluid	高温流体	specific heat
	Low Temp. Fluid	低温流体	specific heat
	Temp. rising (falling)	温度上昇（降下）	
	Flow	流量	m^3/h
	Condensate recovery	ドレン回収	done　　　not done,　　open system,　　closed system
	Rate of Recovery	回収率	%

2-3 Boiler (ボイラ)

1	Part	工　程	
2	Use	用　途	
3	No. of Boiler	番　号	
4	Type	型　式	Water tube boiler (水管) Flue tube boiler (炉筒) Once-through boiler (貫流) Hot-water boiler (温水) Other (その他)
5	Rated evaporation	定格蒸気量	t/h
6	Manufacture date	製造年月日	
7	Steam pressure	圧　力	Rated (定格) kg/cm2G, Normal (常用) kg/cm2G
8	Heating surface area	伝熱面積	m^2
9	Auxiliary Equip.	附属設備	Superheater (過熱器) m^2, Reheater (再熱器) m^2 Economizer (節炭器) m^2, Air heater (空気予熱器) m^2
10	Fuel Name Lower Calorific Value Specific gravity	燃　料 名　前 発熱量 (低位) 比　重	Kcal/kg,ℓ,m^3N
11	Usage Continuous Batch	使用状況 連　続 非連続	h/d, d/m, h/y,

Diagnoser		Date		Factory	

	Item	項　目	Unit 単位	Nominal 定格	Actual 実績	Remarks 備考
12	Oil Tank	油タンク	——			
	Volume	容量	m^3			
	Temp.	油温	°C			
	Insulation	保温	mm			
	Leak	洩れ	——			good, not good
13	Boiler	ボイラ	——			
	Steam Pressure	蒸気圧力	kg/cm^2G			
	Steam Temp.	蒸気温度	°C			
	Feed water flow rate	給水 給水量	m^3/h			
	" Temp.	温度	°C			
	" Meter	流量計				Type
	Blow off flow rate	ブロー量	m^3/d			Continuous, Intermittance, Heat recovery
	Boiler water	缶水	——			
	pH	ピィエッチ				
	Conductivity	電気伝導率	μS/cm			
14	Feed Water	給水	——			
	pH	ピィエッチ				
	Conductivity	電気伝導率	μS/cm			
	Preparation method	処理法	——			
	Testing time	検査頻度	——			
	Cl' content	クロール濃度	ppm			

	Item	項　目	Unit 単位	Nominal 定格	Actual 実績	Remarks 備考
15	Combustion	燃焼	―――			
	Fuel	燃料				
	Consumption	使用量	ℓ.kg.m^3/h			
	Temp.	温度	°C			
	Meter	計器	―――			exist, not exist
	Burner	バーナー				Oil burner
	Type	型式	―――			Low press, air atomizing (低圧噴霧式) Steam or air atomizing (高圧噴霧式) Press. jet type (油圧式) Rotary (回転式) Gas burner Intermixing type (内部混合式) Injector atomizer (外部混合式) Semi-mixing (半混合式)
	Capacity	容量	ℓ.kg.m^3/h			
	Burner tile	バーナータイル	―――			good, not good
	Clinker	クリンカー	―――			found, not found
	Air ratio	空気比	―――			Measuring point (場処)
	Insulation	断熱	mm			good, not good　surface temp. heat flux.
	Sucking air	侵入空気	―――			good, not good
16	Color of smoke	煙の色	―――			good, not good
17	Air heater	空気予熱器	―――			exist, not exist
	Air temp.	空気温度	―――			
	Inlet	入口	°C			
	Outlet	出口	°C			

	Item	項　目	Unit 単位	Nominal 定格	Actual 実績	Remarks 備考
	O_2 % Inlet	入口	%			
	Outlet	出口	%			
	Waste gas temp.	排ガス温度	―――			
	Inlet	入口	°C			
	Outlet	出口	°C			
18	Economizer	エコノマイザー	―――			exist, not exist
	Waste gas temp.	排ガス温度	―――			
	Inlet	入口	°C			
	Outlet	出口	°C			
	Feed water temp.	給水温度	―――			
	Inlet	入口	°C			
	Outlet	出口	°C			
19	Automatic Controller	自動制御	―――			exist, not exist
	Subject	対象	―――			Steam press. air ratio
	System	方式	―――			
	Operation	作動	―――			good, not good
20	Steam accumulator	スチームアキュムレーター	―――			exist, not exist
	Capacity	容量	m^3			
	Pressure	圧力	kg/cm^2G			
22	Evaporation ratio	蒸発倍数	Kg/kg,ℓ			
	Boiler efficiency	ボイラ効率	%			Hh base, Hl base
	Loss with waste gas	排ガス損失	Kcal/h			

	Item	項　目	Unit 項目	Nominal 定格	Actual 実績	Remarks 備
23	Soot blow	スートブロー	/d			
	Service a burner	バーナー手入	/m			
	Removal of scale	スケール除去	———			
	Air heater	空気予熱器	/y			
	Economizer	エコノマイザー	"			
	Gas duct	煙　道	"			
	Stack	煙　突	"			
	Cleaning burner tip	バーナチップ手入	/m			

2-4 Steam Piping, Condensate Recovery (蒸気管, ドレン回収)

Steam Piping Insulation Leakage	蒸気配管 保温 漏洩				
Recovery of Flashed Steam Cylinder Hood	フラッシュ蒸気の利用 シリンダー上のフード	exist, not exist 有 無			
Condensate Recovery Flow Rate System	ドレン回収 発生量 回収率 回収方式	m^3/h % open, closed			
Steam Trap Type No. of Unit Present Condition	スチームトラップ 形式 数量 作動状況	good, not good			
Flow Sheet Steam Condensate	フローシート 蒸気 ドレン				

Diagnoser	

Date		Factory	

3. Electric Power Management

3-1 Electric Power Management（電力管理）

1	General	一般				
	(1) Record of used power for every month	毎月の使用電力量（KWH）の記録	done		not done（理由）	
	(2) Examination the cause for variance for used power	使用電力量が変化した理由の検討	done		not done	
	(3) Stability of voltage and frequency of source	受電電圧，周波数の安定状況	stable		not stable	
2	Electric power specific unit (EPSU)	電力原単位				
	(1) Calculation for major product's EPSU monthly	毎月の主要製品の電力原単位の算出	Yes		No	
	(2) Preparation table on the right for every process and use	用途別・工程別に右表があるか	Output (A) 生産量A)	Used power (B) 電力使用量(B)	EPSU (B/A) 原単位(B/A)	ratio of electric power fee per total cost 生産費に占める電力割合費
	(3) Numerical EPSU target	電力原単位の目標値	決めている determined (value)		決めていない not determined	
3	Load Factor	負荷率				
	(1) Record of hourly consumption of power	毎時間の消費電力の記録	記録している done (max. kWh) (min.)		記録していない not done	
	(2) Daily load curve graph	日負荷曲線	グラフ化している done		していない not done	
	(3) Improvement of load curve	日負荷の最大値を抑える対策	行なっている done		行なってない not done	
4	Value of power factor contracted	電力料金算定上の力率				
	(1) Supplier	電力会社				
	(2) Penalty fee	ペナルティ				

Diagnoser	

Date		Factory	

<table>
<tr><td>5</td><td>Substation</td><td>受変電設備</td><td></td></tr>
<tr><td></td><td>(1) Meters at receiving panel and adequancy of indication</td><td>受電盤の計器の有無とその指針の良否</td><td>
<table>
<tr><td>Meter 計器</td><td>Voltage 電圧</td><td>Ampere 電流</td><td>kW 電力</td><td>kWh 電力量</td><td>Power Factor 力率</td><td>kVr 無効電力</td><td>kVrh 無効電力量</td></tr>
<tr><td>Primary 一次側</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Secondary 二次側</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Note 備考</td><td colspan="7">Good
Not good</td></tr>
</table>
</td></tr>
<tr><td></td><td>(2) Measurement of transformer load</td><td>変圧器の負荷測定</td><td>Yes No</td></tr>
<tr><td></td><td>(3) Transformer exclusively for lighting</td><td>電灯用専用変圧器</td><td>Yes No</td></tr>
<tr><td></td><td>(4) Turning off transformer when off load</td><td>不要時の変圧器遮断</td><td>Yes No</td></tr>
<tr><td></td><td>(5) Improvement of power factor by static condenser</td><td>コンデンサーによる力率改善</td><td>Yes No</td></tr>
<tr><td></td><td>(6) One-line diagram</td><td>配線系統図の有無</td><td>Have No</td></tr>
<tr><td>6</td><td>Distribution system</td><td>配線設備</td><td></td></tr>
<tr><td></td><td>(1) Measurement of main circuit load</td><td>主回路別の負荷測定</td><td>Yes No</td></tr>
<tr><td></td><td>(2) Rate of voltage drop of main circuit</td><td>主回路別の電圧降下率</td><td></td></tr>
<tr><td></td><td>(3) Balance in three phases</td><td>相間のバランス</td><td>Voltage ____________ , Current ____________</td></tr>
<tr><td>7</td><td>Motor</td><td>電動機</td><td></td></tr>
<tr><td></td><td>(1) Measurement of load of motors over 15 kW</td><td>15kw以上の電動機の負荷測定</td><td>Yes No</td></tr>
<tr><td></td><td>(2) Periodically lubrication of gear and motor</td><td>ギヤや電動機の定期的な給油</td><td>Yes No</td></tr>
<tr><td></td><td>(3) Turning off motor when off load</td><td>無負荷時の電動機の停止</td><td>Yes No</td></tr>
</table>

8	Motor driven machine	電動機応用設備	
	(1) Flow control of blower and pump	ブロワーやポンプの流量制御	Motor speed control 電動機の速度制御 Control of numbers of operating motor 台数制御 Damper or valve control ダンパー，バルブの開閉 Others その他
	(2) Checking leakage of compressed air or water	圧縮空気や水のもれのチェック	Yes No
	(3) Keeping adequate working pressure of compressed air	圧縮機の使用圧力は適正か	Yes No
	(4) Keeping adequate discharge pressure of pump	ポンプの吐出圧は適正か	Yes No
9	Lighting fittings	照明設備	
	(1) Cleaning lighting fittings	照明器具の清掃	Yes No
	(2) Turning off unnecessary light	不要な照明の消灯	Yes No
10	Electric welder	電気溶接機	
	(1) Static condenser exclusively for welder	専用の力率改善用コンデンサー	Yes No
	(2) Transformer exclusively for welder	専用の変圧器	Yes No
	(3) Keeping circuit balance of three phases	電源の各相のバランス	Yes No
	(4) Cable length from welder to holder	溶接機の手元までの配線長さ	Yes No
	(5) Primary cutout type voltage reducing device	一次切入式電撃防止器の有無	Yes No
11	Classification of load 負荷の配分		

Machines 主機のモーター	Air Compressors コンプレッサ	Pumps ポンプ	Heaters ヒーター	Lighting 照明	Air Conditioner 空調	Total 合計
kW	kW	kW	kW	kW	kW	kW
%	%	%	%	%	%	100.0 %

3-2 Transformer for (変圧器)

1	Type of Transformer	型式	☐ Oil Immersed Self Cooling (油入自冷式) ☐ Dry Type (乾式) ☐ Air cooling Forced Oil (送油風冷式) ☐ Others (その他)
2	Number of Phase	相数	☐ 3 Phase (三相) ☐ Single Phase (単相)
3	Connection (Single Phase)	結線方法 (単相Tr)	☐ Δ - 人 ☐ 人 - Δ ☐ Δ - Δ ☐ V - V
4	Rated Output	定格出力	______ kVA, Number of Bank (バンク数) ______
5	Rated Voltage Rated Current	定格電圧 定格電流	Primary ____ V, ____ A Secondary ____ V, ____ A
6	Rated Frequency	定格周波数	____ Hz. | 7 | % Impedance パーセントインピーダンス | ____ % At ____ kVA Base
8	Maker, Year Made	メーカと製造年	
9	Loss	損失	Iron Loss (鉄損) ____ kW, Copper Loss At Full Load (全負荷銅損) ____ kW,

Measurement Record (測定記録)

Time 時間	Voltage 電圧	Current 電流	Apparent Power 皮相電力	Power 電力	Power Factor 力率	Oil Temp. 油温	Remarks 備考
	V	A	kVA	kW	%	°C	

Diagnoser	

Date		Factory	

3-3 Motor Driven Machine except Air Compressor ∿ Over 15 kW (電動力応用設備コンプレッサを除く～15kW以上)

1	Name of Equipment	設備名	Number of Similar Equipment 同種設備の数 ____
2	Kind of Motor	電動機の種類	☐ D.C. (直流) ☐ Inductor (誘導機) — ☐ Wound Rotor / ☐ Squirrel Cage ☐ Others ____ ☐ A.C. (交流) ☐ Syncronous (同期機)
3	Rating of Motor	電動機の定格	Output (出力) ___ kW, Voltage (電圧) ___ V, Current (電流) ___ A Frequency (周波数) ___ Hz, RPM (回転数) ___ rpm, Magnetic Pole (極数) ___
4	Starting Method	起動方法	☐ Full-Voltage (直入) ☐ Star-delta (人-Δ) ☐ Rotor-resistance (二次抵抗) ☐ Others ____
5	Coupling Apparatus	伝導装置	☐ Direct (直結) ☐ Belt (ベルト) ☐ Gear (歯車) ☐ Others ____ Material (材質) ☐ Natural (自然物) ___, Tension (弛度) ___ ☐ Synthetic (人工物) ___, Number (本数) ___
6	Equipment	設備機械	☐ Pump (ポンプ) ☐ Blower (ブロワー) ☐ Others ____
7	Kind of Flow and Density	流体名と密度	☐ Air (空気) ☐ Water (水) ☐ Others, ____ ☐ Density (or Specific Gravity) (密度又は比重) ____ kg/m^3 (lb/m^3)
8	Flow Control	流量制御	☐ Automatic (自動) ☐ Manual (手動) { ☐ Valve (バルブ) ☐ Damper (ダンパー) ☐ Speed Control (速度制御) ☐ Others ____ }
9	Speed Control	速度制御	☐ Motor (モーター) { ☐ Pole Change (極数) ☐ Frequency (周波数) ☐ Voltage (電圧) ☐ Others ____ } ☐ Mechanical (機械式)
10	Automatic Cutting-off (When Off-Load)	空転時の自動停止装置	☐ Yes (有) ☐ No (無)
11	Frequency of Lubrication	給油頻度	____ times/year (回/年) | 12 | Frequency of filter cleaning | 吸入フィルター清掃 | ____ times/Month

Diagnoser			

Date		Factory	

Motor driven machine （電動機応用設備）

Name of machine ________________

Date	Used power 使用電力				Used power /rated power x 100% 使用電力/定格電力	Temp. of fluid °C 流体温度	Flow Q m^3/min 流量 Q' t/h		Fluid 液体		Valve Position バルブ開度 管径cm	Velocity of fluid m/s 流速	Estimated Load kW 推定負荷	Efficiency % 総合効率	Remarks (Sound Vibration Leakage Others) 備考
	Voltage V 電圧	Current A 電流	Power factor % 力率	Electric power kW 電力			Rated 機器の定格	Actual 測定値 max. min.	Pressure H' kg/cm^2 Hm 圧力	Pipe Inner Diameter					

1) Required electric power of blower 送風機所要電力

$$P = \frac{A \cdot Q \cdot PT}{1{,}000 \cdot \eta \cdot 6.12} \text{ (kW)}$$

PT: Total pressure (mmAq) 全圧, A: Allowance (1.1-1.3) 余裕率, η: efficiency of blower (0.72-0.78%) 送風機効率

2) Required electric power of pump

$$P = \frac{A \cdot \gamma \cdot Q \cdot H}{\eta \cdot 6.12} \text{ or } P = \frac{Q' \cdot H'}{\gamma \cdot \eta \cdot 36.7} \text{ (kW)}$$

A: allowance (1.05∿1.2) 余裕率, η: efficiency of pump ポンプ効率 (0.8∿0.85%)

3) Velocity of fluid 配管内流速

$$U = \frac{Q}{A} \text{ (m/sec)}$$

Q: flow (m^3/sec) 流量

A: sectional area of pipe (m^2) 管内断面積

Adequate velocity

	velocity (m/sec)	pressure (Kg/cm^2)
City water 水道水	0.6 ∿ 1.5	1.8 ∿ 3.0
River water 一般水	1.5 ∿ 3.0	3.0 ∿ 10
Air 空気	8 ∿ 15	1 ∿ 2

3-4 Operation of Motors （モーターの稼動状況）

Process 工 程	Used for 用 途	Maker メーカー	Year built 製造年	Output 容 量	No. 台 数	Voltage 電 圧	Current 電 流			Revolu- tions 回転数	Speed control 速度制御	Power factor 力 率	Note 備 考
							Rated 定格Ⓐ	Actual 実測Ⓑ	Ⓑ/Ⓐ				
				kW HP		V	A	A	%	r.p.m.		%	

Diagnoser		Date		Factory	

3-5 Air Compressor （エアコンプレッサー）

Process 工程	Use for 用途	Pressure 圧力	Volume 圧縮量	Input 入力	Type 型式		No. 台数	Installation 設置方式		On-off Operation 台数制御		Cooling Water Temp. 冷却水温度		Air leakage 漏気				
					Oil	Oil-less		Centra-lized	Sepa-rated	Yes 有	No 無	Inlet 入口	Outpet 出口	Ratio 率	Body 本体	Pipe パイプ	Valve バルブ	Joint 接手
					reci-pro. screw	reci-pro. screw												

Diagnoser	

Date		Factory	

3-6 House Power Plant (自家用発電設備)

1	Kind of Engine	エンジンの種類	☐ Diesel Engine ☐ Gas Turbine		☐ Steam Turbine ☐ Condensing turbine ☐ Back Pressure Turbine ☐ Extraction and Back Pressure Turbine		
2	Output of Engine	エンジン出力	______ PS(kW)	3	Fuel Consumption	燃料消費量	______ ℓ(Kg)/h
4	Kind of Fuel	燃料種別	☐ Coal ☐ Heavy Oil ☐ Diesel Oil ☐ Others				
5	Caloric Value of Fuel	同上の発熱量	______ Kcal/ℓ(Kg)				
6	Rated Output of Generator	発電機の定格出力	______ kVA(kW)	7	Rated Power Factor	定格力率	______ %
8	Rated Voltage, Rated Current	定格電圧 定格電流	______ V ______ A				
9	Daily Record	運転日誌	☐ Yes (有) ☐ No (無)				

Measurement Record (測定記録)

Time 時間	Generated Energy 発電量	Fuel Consumption 燃料消費量	Steam Temp. 蒸気温度	Steam Pressure 蒸気圧力	Voltage 電圧	Current 電流	Power Factor 力率	Remarks 備考
	kWh	Kg	In. °C Out	In kg/ Out	V	A	%	

Diagnoser		Date		Factory	

3-7 Air Conditioner (空調設備)

1	Type of System	空調方式	☐ Air Duct Conditioning (集中方式) ☐ Fan Coil Unit (ファンコイル方式) ☐ Unit Air Conditioning (パッケージ方式)
2	Room Air Conditioned (1) Room Size	室の状況 室の大きさ	Floor Space (床面積) ____ m^2, Room Volume (室容積) ____ m^3
	(2) Number of person in the Room	室内人数	____ 人
	(3) Usage	用途	☐ Office (事務室) ☐ Works (工場) ☐ Others
	(4) Room Temp.	室温	Actual Temp. (実測温度) ____ °C Set Temp. (設定温度) ____ °C Measurement Method (測温方式) ☐ Manual ☐ Automatic Control Method (制御方式) ☐ Manual ☐ Automatic
	(5) Humidity	湿度	Actual (実測湿度) ____ (設定湿度) ____ Measurement Method (測定方式) ☐ Manual ☐ Automatic Control Method (制御方式) ☐ Manual ☐ Automatic
	(6) Air Flow	風量	Fresh Air Flow Induced (外気取入風量) ____ m^3/min, Circulating Air Flow (室内循環風量) ____ m^3/min.
3	Water Cooling Tower	クーリングタワー	Actual Temp. (実測温度) ____ °C, Wet Bulb Temp. (湿球温度) ____ °C, Flow (水量) ____ ℓ/min., Delivery Press. (吐出圧) ____ kg/cm^2G
4	Type of Refrigerating Machine	冷凍機の種類	☐ Compression Type (圧縮式) ☐ Absorption Type (吸収式)
5	Refrigerant	冷媒	☐ Ammonia (アンモニア) ☐ Freon (フロン) ☐ High Pressure (高圧) ☐ Low Pressure (低圧)

Diagnoser		Date		Factory	

6	Cleanness of Air (1) Method for removement of flying cotton	清　浄　度 風綿除去方式	☐ Nozzle absorbing (ノズル吸込) ☐ Traveling absorber (巡回吸込) ☐ Floor duct (床面吸込) ☐ Air conditioner (空調機) ─ ☐ Wiper (ワイパー式) / ☐ Blowoff (ブローオフ式)	
	(2) Method for electrostatic shielding	静電防止方式	Humidifier (給湿機)	Electric (電気方式)
7	Insulation of roof and wall	屋根，壁の断熱	good	not good
8	Insulation of duct and pipe	ダクト，配管の断熱	good	not good
9	Tightness of window and door	窓，ドアの気密	good	not good
10	Separation heat generating equipment	発熱機器の分離	yes	no
11	Partial air conditioning in large room	大空間の中の空調を要する部分の隔離	yes	no
12	Heat recovery by total enthalpy heat exchanger	全熱交換器による熱回収	yes (Type　　　　)	no
13	Water spray on roof	屋　根　散　水	done	not done
14	Starting and stopping time of air conditioner	装置の起動停止時刻	Starting time ____________ Stopping time ____________	
15	Stopping water pump when refrigerating machine stops	冷凍機停止時に冷却水ポンプの停止	stop (auto, manual)	not stop
16	Prevention over cooling and stopping when unnecessary	過冷防止，不要時の運転停止	yes	no

17	Setting most suitable temperature by climate	季節による設定温度の変更	yes	no
18	Control of induced fresh air	必要外気量の管理	yes	no
19	Checking temperatures of evaporation, condensation and pressure of refrigerating machine	冷凍機の蒸発温度，凝縮温度の管理，制御圧の管理	yes	no
20	Cleaning (Condenser)	清掃（冷凍用コンデンサー）	done (times/month)	not done
21	Cleaning (Air Conditioner Coil)	清掃（空調用コイル）	done (times/month)	not done
22	Cleaning (Air Filter)	清掃（エアフィルター）	done (times/month)	not done
23	Cleaning (Cooling Tower)	清掃（クーリングタワー）	done (times/year)	not done

Air Conditioner Measurement Record No.1 （空調測定記録 その1.）

	Inlet Fan	Circulating Fan	Cooling Tower		Refrigerating Machine （冷凍機）	
			Pump （ポンプ）	Fan （ファン）	Compression Type （圧縮式）	Absorption Type （吸収式）
	（外気取入ファン）	（室内循環用ファン）				
Rated （定格）	kW	kW	kW	kW	kW	Kcal/h
Actual （実測）	kW	kW	kW	kW	kW	Kcal/h

Air Conditioner Measurement Record No.2 (空調測定記録 その2.)

Place (場所)									
Temperature 温度	Set 設定	°C							
	Actual 実測	°C							
Humidity 湿度	Set 設定	%							
	Actual 実測	%							
Cleanness of Air 清浄度									
Insulation 断熱	Ceiling 天井	Material 材質							
		Thickness 厚み							
	Wall 壁	M. 材質							
		T. 厚み							
	Floor 床	M. 材質							
		T. 厚み							
	Window 窓	Double glass 二重ガラス							
		Heat-absorbing glass 熱線吸収ガラス							
		Blinds ブラインド							
Tightness of Room 密閉状況									
Heat source 熱負荷	Persons 人	人							
	Motor モーター	台							
	Lighting 照明	kW							
	Steam or Fuel スチーム								
	Heater 電熱	kW							

3-8 Lighting Fittings （照明設備）

1	Lighting System	工場照明方式	☐ General（全般照明） ☐ General and Local（全般照明と局部照明）
2	Method of Turning On and Off	点滅方法	☐ Automatic（自動点滅） ☐ Manual（手動点滅） ☐ Both Automatic and Manual
3	Circuit Separation (In case of General Lighting)	全般照明の場合の回路方式	☐ One Switch per Room（1ルーム、1スイッチ） ☐ Several Switches per Room（1ルーム 複数スイッチ） ☐ One Switch per Line (Turn, Line by Line from Window side)（ライン毎に点滅）
4	Kind of Lamp	ランプの種類	☐ Incandescent Lamp（白熱灯） ☐ Fluorescent Lamp (daylight color) 昼光色蛍光灯 ☐ Fluorescent Lamp (White)（白熱蛍光灯） ☐ Fluorescent Mercury Lamp（蛍光水銀灯） ☐ Energy Conservation Type F.L.（省エネ型蛍光灯） ☐ Good-color High Pressure Sodium Lamp（高演色型高圧ナトリムウ灯） ☐ Others ______
5	Cleaning Frequency of Lighting Fittings	照明器具の清掃頻度	______ Times/Year（回／年）
6	Utilization of Daylight	昼光利用	☐ Glass ガラス ☐ Vinyl chloride 塩化ビニール ☐ Polystyrene スチロール ☐ Acryl resin アクリライト ☐ Polycarbonate ポリカーボネート ☐ Others その他

Measurement Record（測定記録） Time at AM/PM ______（測定時刻）

Place（場所）									
Illuminance（照度）									
Distribution of Illuminance（照度分布）									
Kind of Lamp（ランプの種類）									
Wall Color（壁の色）									

Power Consumption for Lighting（照明用消費電力） Day Time（昼間） kWh/h Night（夜間） kWh/h from daily record 日誌から

Diagnoser	

Date		Factory	

INSTRUMENTS LIST

No.	Instrument	type
1	Hotwire Anemometer	V-02-A700
2	Heat Insulation Tester	MH2
3	Portable Oxygen Meter	6232
4	Pocket Thermometer	2542
5	Thermopetter	400
6	Portable Radiation Thermometer	IR-HP2
		IR-HP3
7	Pocket Conductivity Meter	SC51
8	Pocket PH Meter	PH51
9	Lux-Meter	ANA999
10	Clip-on AC Power Meter	2433-11
11	Clamp-on Power Hi Tester	3136
12	Integrator	3141
13	Digital Printer	3171
14	Volt Slider	S-260-5
15	Multitester	3009
16	Portable Thermo Indicater	M-350
17	Voltage Detector	
18	Revolution Indicater	
19	Digital Pressure Gauge	DLM1-10
20	Ultrasonic Audio-Visual Checker	UC-1