UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
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UNITED NATIONS

INDUSTRIAL DEVELOPMENT ORGANIZATION

THE FINAL REPORT

ON

PROGRAMME FOR RATIONAL USE OF ENERGY RESOURCES

IN

CERAMIC AND CEMENT INDUSTRY

IN

BANGLADESH AND SRI LANKA

UNIDO Contract : 94/014

Project No : US/RAS/93/039

The Energy Conservation Center, Japan

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CONTENTS

1. Preface

The Energy Conservation Center, Japan(ECC) has been contracted by UNIDO for the subcontract to execute the project. The services required from the subcontractor comprised; (1) Implementation of plant surveys in Bangladesh and Sri lanka including supervision of the local counterparts and (2) Organization of a seminar, delivering lectures and taking care of the dissemination of technical manuals in Bangladesh and Sri Lanka.
Both tasks have already been completed on schedule in accordance with the Terms of Reference of the subcontract.
The final report describes the results of all the duties including the activities and evaluation.

A remarkable increase in energy demand, particularly in the South East Asian countries, has been noted in recent years. The growing economy of the Asian countries is expected to continue at rapid pace, together with a corresponding increase in energy consumption.
Energy Conservation simply means rational use of energy. It is and effective way of promoting industrialization and advancement in every country in the world. As the international trade competition power becomes stronger, the companies adopting energy conservation can have a competitive edge in the market through low production cost.

In addition, the world environmental issue is a subject of highest importance. The most effective solution to the environmental problem is said to be energy conservation.
UNIDO has been actively engaged in the promotion of a program in this field. Joint technical assistance activities of UNIDO and Japan will contribute to the development of economies and human life in Asian countries through this programme. This activity owes much to the Industrial Sectors and Environment Division of UNIDO for helpful suggestions and special assistance.
This report is a summary of the Program for Rational Use of Energy Resources in ceramic and cement industries, and includes a seminar held in May 1994 and a field survey carried out in September 1993, both in Bangladesh and Sri Lanka.

2. Outline of the programme

This programme is to prepare the handy manuals for rational use of energy sources in ceramic and cement industries in industrial enterprises in developing countries.
The activities in the programme are as follows:

July 1993:

- Assignment of 2 experts in ceramic and cement industries in Japan

September 1993:

- Field survey in ceramic and cement industries in Bangladesh and Sri Lanka by the experts

September 1993 to January 1994:

- Preparation of the draft handy manuals in ceramic and cement industry by the experts in Japan

April 1994:

- Submission of 3 copies of the draft handy manuals in ceramic and cement industry to UNIDO

May 1994:

- Holding of seminars for dissemination of rational use of energy source in ceramic and cement industries in Bangladesh and Sri Lanka with the draft handy manuals

January 1995:

- Submission of 600 copies of the final handy manuals in ceramic and cement industry to UNIDO

3. Evaluation of the seminar

This study attempts to evaluate the seminar on the programme for rational use of energy resources in ceramic and cement industries in Bangladesh and Sri Lanka held by the United Nations Industrial Development Organization(UNIDO) and the Ministry of International Trade and Industry(MITI), Japan, organized by the Energy Conservation Center(ECC), Japan and hosted by the Ministry of Energy and Mineral Resources, Bangladesh and the Ministry of Power and Energy, Sri Lanka on 11th to 12th May Sonargaon Hotel in Dhaka and on 18rd to 19th May at Hilton Hotel in Colombo, in 1994. 40 to 60 participants from government agencies, mostly factories attended the seminar.

In Bangladesh the known energy resources are natural gas, coal, peat, hydropower, biogas and renewable energy sources. 62% of commercial energy demand is covered by natural gas. Considering a 10% growth in annual demand the presently known gas reserves of 10.7 TCF would serve up to the year 2010. 32% of commercial energy demand is covered by oil, 98% of which is imported. 40% of commercial energy is consumed by the industrial sector. The government of Bangladesh has enforced the National Energy Conservation Policy Act. In order to carry out the policy declared in this Act, the Government established the Energy Monitoring and Conservation Centre(EMCC). EMCC promotes energy saving through energy audits and introduction of energy efficiency technology.

In Sri lanka biomass, hydropower and fuel wood are available as primary energy resources in the country. 71% of the energy supply is covered by fuel wood and biomass resources, 18% by oil and 10% by hydro electricity. All crude oil is imported from other countries. Consumption of commercial energy in 1990 (Electricity and petroleum) by sector break down into transport 53.4%, Industry 18.4%, domestic 19.1% and commercial 9.1%. Transport consumes only petroleum products. From 1977 to 1993 the average annual consumption rose to 9.5% spurred by the opening of the economy, new industries in the Export Promotion Zone, the booming tourist industry and general expansion of the services sector. In 1985 a non governmental Sri Lanka Energy Managers Association was established to upgrade energy management skills in the private sector, carry out energy audits and take effective measures for saving energy in industry. A project Ministry for Energy Conservation created in March 1990 to promote identified energy conservation programmes.

Under these circumstances,the UNIDO seminars were held for the purpose of increasing awareness and knowledge of government officials and factory engineers in good time. The number of participants of the seminar amounted to 40 to 60 persons for each day. All participants were observed to be attentive audience having interest in most of subject. Two experts pointed out the important items of energy conservation technologies in both ceramic

and cement industries using textbooks (draft handy manuals) based on the results of the factory survey in Bangladesh and Sri Lanka. The seminar was covered with general energy conservation ideas in both ceramic and cement industries. Responses of participants were very favorable and seminar could be considered to have been very successful.
There are five important factors for the success of this seminar as follows.

1) Many participants from factories

This seminar had many participants among factory engineers who needed basic energy conservation technology of factory operation. ECC has many experiences on this kind of technology for more than 15 years, in organizing field survey, training course, and seminar for participants from developing countries. At this point, participants from factories could take advantage to operate in order to promote energy efficiency in factories. Many participants from factories could gain these technologies.

2) Government - Factories Cooperation

Through this seminar strong pipe connection have been made up between government and private sector. It is useful to future cooperation of both of them.

3) Establishment of key countries to other developing countries

Both countries of Bangladesh and Sri Lanka can be key countries to exchange information of energy conservation through this seminar. Because this seminar was very important to transfer the awareness of energy conservation.

4) Enforcement of energy conservation awareness for counterparts

It should be emphasized that the success of this seminar largely depends upon the quality of cooperation given by local counterparts. Counterparts of both countries made great efforts and they did every arrangement of the seminar. This experience should be inherited in the future.

5) Additional seminar

In addition to seminars of energy conservation in ceramic and cement industries, we carried out the seminar concerning demonstration of factory energy audit. Through this additional seminar by ECC, participants could further understand the importance of the daily energy management for factory operation. We think this kind of combined seminar is very useful to get the comprehensive understanding.

Future output of this project will be the following three points.

1) Seminar on successful cases of both industries will be effective to recognize the importance of energy conservation.

2) Energy conservation seminars for persons in charge of energy management in small and medium size factories will be very important.

3) Workshops on factory energy audit will be useful for promotion and dissemination of energy conservation in industrial field.

4. Schedule of the seminars

May	8	1994	Narita(11:00) to Bangkok(15:00) TG641
	9		Bangkok(15:00) to Dhaka(16:20) TG513
	10		Preparation of seminar
	11		Seminar, Cement industry
	12		Seminar, Ceramic industry
	13		Off day (Saturday)
	14		Dhaka(14:00) to Bangkok(17:10) TG322
	15		Bangkok(10:40) to Colombo(12:25) TG307
	16		Preparation of seminar
	17		Preparation of seminar
	18		Seminar, Cement industry
	19		Seminar, Ceramic industry
	20		Colombo(13:25) to Bangkok(18:15) TG308
			Bangkok(23:45) to Narita TG642
	21		Ar.Narita(7:30) TG642

1) Seminar program in Bangladesh

11 May 1994, at Sonargaon Hotel, Dhaka

Seminar on Energy Conservation in Cement Industry

8:30-9:30	Registration of Participants
9:30-10:15	Opening Ceremony Welcome Address by Mr. Sazzadur Rahman, Director, EMCC, Minisry of Energy and Mineral Resources Adress by Mr. G.L.Narashiman, Country Director, Dhaka, United Nations Industrial Development Organization(UNIDO) Address by Mr. Norio Fukushima, General Manager, Japan International Energy & Environment Cooperation Center(JIEC), The Energy Conservation Center, Japan (ECCJ) Special Guest Address by Mr. Yoshiyuki Kuroda, Minister, Embassy of Japan Special Guest Address by Mr. Mahammad Faizur Razzaque, Secretary, Ministry of Energy and Mineral Resources Chief Guest Address by Dr. Khandakar Mosharrag Hossain, Minister for Energy and Mineral Resources
10:15-10:45	Tea Break
10:45-12:30	Lecture by Mr. Hisashi Ikeda: - Energy Conservation in Cement Industry(1)
12:30-13:30	Lunch and Prayer
13:30-15:00	Lecture by Mr. Hisashi Ikeda: - Energy Conservation in Cement Industry(2)
15:00-15:30	Tea Break
15:30-16:30	Discussion

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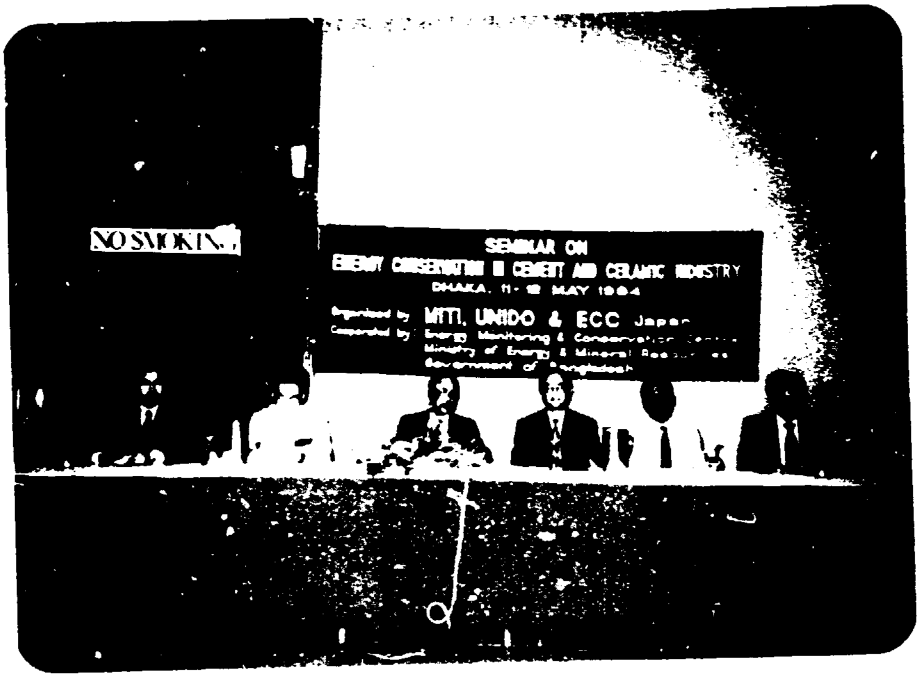
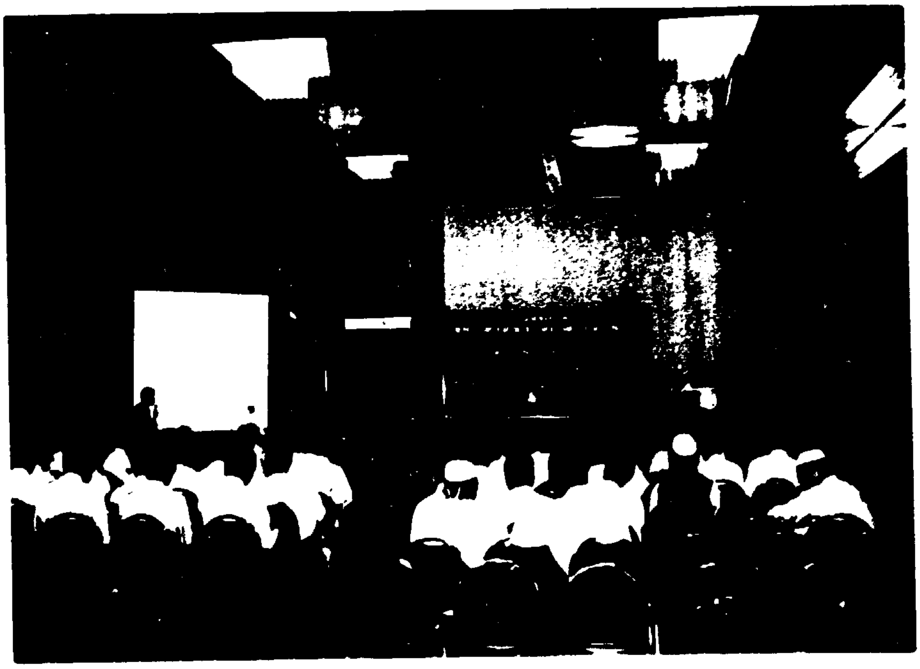
12 May 1994, at Sonargaon Hotel, Dhaka

Seminar on Energy Conservation in Ceramic Industry

8:30–9:15	Registration of Participants
9:15–11:00	Lecture by Mr. Motomu Ishikawa: - Energy Conservation in Ceramic Industry
11:00–11:30	Tea Break
11:30–13:00	Lecture by Mr. Motomu Ishikawa: - Energy Conservation in Ceramic Industry
13:00–14:00	Lunch and Prayer
14:00–15:00	Discussion
15:00–15:30	Tea Break
15:30–17:00	Demonstration of Factory Energy Audit by Mr. Norio Fukushima
17:00	Closing Address by Mr. Sazzadur Rahman, EMCC Address by Mr. Norio Fukushima, ECCJ Address by Mr. Hassan Nazemi, UNIDO



Picture on seminar (1)



Picture on seminar (2)

Seminar in Bangladesh

2) Seminar program in Sri Lanka

18 May 1994, at Hilton Hotel, Colombo

Seminar on Energy Conservation in Cement Industry

8:30-9:30	Registration
9:30-10:15	Inauguration Ceremony Lighting of Traditional Oil Lamp Welcome Address by Mr. W.R.B.Rajakaruna, Secretary, Energy Conservation, Ministry of Power & Energy Address by Mr. A. Hassan Nazemi, Industrial Development Officer, Environment and Energy Branch, Industrial Sectors and Environment Division, UNIDO Address by Mr. Hiro Moribe, Resident Representative, Japan External Trade Organization(JETRO) Colombo Address by Mr. Norio Fukushima, General Manager, Japan International Energy & Environment Cooperation Center(JIEC), The Energy Conservation Center, Japan (ECCJ) Chief Guest Address by Hon. sarathchandra Rajakaruna, Minister of Energy Conservation, Acting Minster of Power and Energy
10:15-10:45	Tea Break
10:45-12:30	Lecture by Mr. Hisashi Ikeda: - Energy Conservation in Cement Industry(1)
12:30-13:30	Lunch
13:30-15:00	Lecture by Mr. Hisashi Ikeda: - Energy Conservation in Cement Industry(2)
15:00-15:30	Tea Break
15:30-16:30	Discussion

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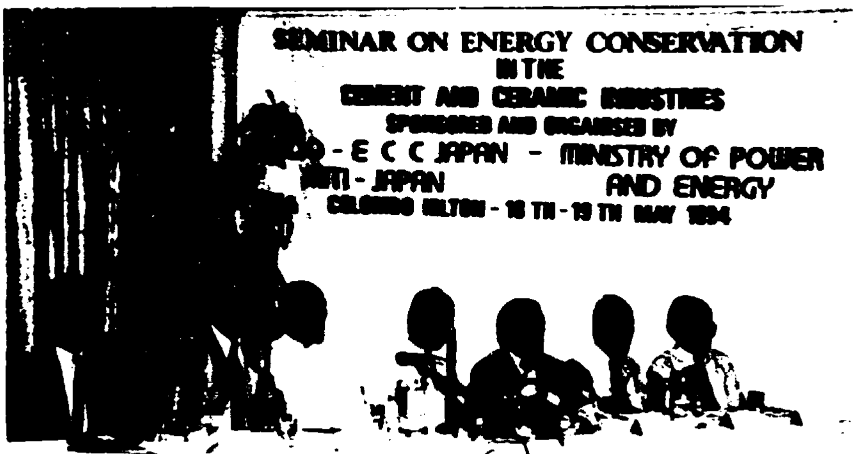
19 May 1994, at Hilton Hotel, Colombo

Seminar on Energy Conservation in Ceramic Industry

8:30–9:15	Registration of Participants
9:15–11:00	Lecture by Mr. Motomu Ishikawa: – Energy Conservation in Ceramic Industry
11:00–11:30	Tea Break
11:30–13:00	Lecture by Mr. Motomu Ishikawa: – Energy Conservation in Ceramic Industry
13:00–14:00	Lunch and Prayer
14:00–15:00	Discussion
15:00–15:30	Tea Break
15:30–17:00	Demonstration of Factory Energy Audit by Mr. Norio Fukushima
17:00	Closing Address by Mr. G.T.Fernando, Director, Energy(D & I) Address by Mr. Hassan Nazemi, UNIDO



Picture on seminar (1)

Picture on seminar (2)

Seminar in Sri Lanka

5. Schedule of the factory survey

September	7	1993	Narita(11:00) to Bangkok(15:00) TG641
	8		Bangkok(11:30) to Dhaka(12:50) TG321
	9		Visit to UNIDO Dhaka Office, Energy Monitoring & Conservation Center, Ministry of Energy & Mineral Resources, Embassy of Japan in Dhaka
	10		Dhaka(10:00) to Bogota(18:30)
	11		Tajima Ceramic Ltd. (Ceramic) Bogota(12:00) to Dhaka(20:00)
	12		Bangladesh Insulator & Sanitary Ware Factory (Ceramic)
	13		Dhaka(13:10) to shirett(13:50) BG403
	14		Chhattak Cement Factory, Sunamganj (Cement) Shirret(16:30) to Dhaka(17:10) BG406
	15		Savar Refractories Ltd. (Ceramic) Bengal Fine Ceramic Ltd. (Ceramic) Modhumati Ceramic Ltd. (Ceramic)
	16		Dhaka(7:00) to Chittagong(7:45) BG411 Chittagong Cement Clinker Graiding Co. Ltd. (Cement) Modern Refractory Co. (Ceramic) Chittagong(15:25) to Dhaka(16:10) BG436
	17		Bengal Ceramic Ltd. (Ceramic) UNIDO Dhaka Office
	18		Dhaka(14:00) to Bangkok(17:00) TG322
	19		Bangkok(10:40) to Colombo(12:25) TG308
	20		Visit to Ministry of Energy Conservation Lanka Ceramic Ltd. (Ceramic)
	21		UNIDO Colombo Office, Embassy of Japan in Colombo
	22		Lanka Walltiles (PVA) Ltd. (Ceramic)
	23		Puttlam Cement Co.ltd. (Cement)
	24		Lanka Ceramic Ltd. Nogombo Factory (Ceramic) Dankoluwa Povcelain Ltd.(Ceramic)
	25		Saturday
	26		Colombo(13:25) to Bangkok(18:15) TG308
	27		Bangkok(11:00) to Narita(19:00) TG640

6. Japanese experts list

1)Field survey

1. Mr. Yukio Nozaki
   Technical Adviser
   The Energy Conservation Center, Japan
2. Mr. Motomu Ishikawa
   Technical Adviser (Ceramic expert)
   The Energy Conservation Center, Japan
3. Mr. hisashi Ikeda
   Technical Adviser (Cement expert)
   The Energy Conservation Center, Japan

2)Seminar

1. Mr. Motomu Ishikawa
   Technical Adviser (Ceramic expert)
   The Energy Conservation Center, Japan
2. Mr. Hisashi Ikeda
   Technical Adviser (Cement expert)
   The Energy Conservation Center, Japan

3)Home office

1. Mr. Norio Fukushima
   Project Leader
   The Energy Conservation Center, Japan
2. Mr. Motomu Ishikawa
   Technical Adviser (Ceramic expert)
   The Energy Conservation Center, Japan
3. Mr. Hisashi Ikeda
   Technical Adviser (Cement expert)
   The Energy Conservation Center, Japan

7. Counterparts list

1) Bangladesh

Mr. Sazzadur Rahman
Director
Energy Monitoring & Conservation Center
Ministry of Energy & Mineral Resources
Government of Bangladesh
741, Baitul Aman Housing Society,
Road No.9, Adabor, Shamoly, Dhaka
Bangladesh
Phone: 880-2-315961/319228,

2) Sri lanka

Mr. G. T. Fernando
Director,
Energy(Development & Implementation)
Energy Conservation Ministry,
Ministry of Power and Energy
P.O.Box 576,Sir Chittampalam A,
Gardiner Mawatha,
Colombo 02
Sri Lanka
Phone: 94-1-449289,
Fax: 94-1-449572

8. Recomendations and Conclusions for follow-up actions

Recommendations and conclusions for follow-up actions in dissemination of energy conservation technologies among developing countries

The energy conservation technologies in cement and ceramic industries are disseminated in Bangladesh and Sri Lanka through factories survey implemented in August in 1993 and seminars held in May in 1994.
Our recommendations on the dissemination activities in energy conservation are shown as follows.

1) Dissemination activities in energy conservation technologies by handy manuals:
   The participants of the seminars may hold group meetings in their companies with the handy manuals.

2) Promotion of improvement of operation technic

2)-1 Cement industry
- a) Adjustment of production capacity balance among raw material mill, cement kiln and cement mill
- b) Feeding size distribution control of finishing mill

2)-2 Ceramic industry
- a) Increase of production yield:
  Low energy intensity is made by high production yield.
- b) Quality control of raw material:
  Foreign matters are not to be mixed in raw material.
  Cleaning work in a factory must be made.
- c) Drying control of semi-products:
  Temperature and moisture must be controlled.
- d) Firing control of products:
  Combustion air volume is to be constant.

3) Promotion of improvement of equipment

3)-1 Cement industry
- a) Change of wet type process to dry type process:
  Energy intensity of wet type kiln is 1,500 kcal/ton which is 2 times higher than that of dry type kiln.

b) Improvement of finishing mill:
- Adoption of closed cycle system
- Adoption of a vertical roller mill

3)-2 Ceramic industry

a) Adoption of a roller hearth kiln for high production capacity:
Energy intensity of a roller hearth kiln is lower than that of a tunnel kiln.

Appendix 1. List of the Surveyed Factories

Appendix 1. List of the Surveyed Factories

Bangladesh

1) Ceramic (seven factories)

1.Tajma Ceramic Industry Ltd.
Kabi Nazrul Islam Sarak (Jhawtola),
Bogra-5800
Tel 051-6160

2.Bangladesh Insulator & Sanitary Ware Factory Ltd.
Bux Nagar, Mirpur,
Dhaka-1216
Tel. 801231, 382528

3.Saver Refractories Ltd
Nayarhat, Savar,
Dhaka
Tel. 06226-518

4.Bengal Fine Ceramics Ltd.
Bhagalpur, Savar,
Dhaka
Tel. 06226-840

5.Madhumati Ceramics Ltd.
Ganda, Savar,
Dhaka
Tel. 06226-225

6.Modern Refractory Co.
Chittagong
Tel.

7.Bengal Ceramic Industries Ltd.
215, Rayar Bazar,
Dhaka-1207
Tel. 325327

2) Cement(two factories)

8. Chhattk Cement Co. Ltd.
Chattak,
Sunamganj
Tel. 821-5216

9. Chitttagong Cement Clinker Griding Co.
South Halishahar,
Chittagong
Tel. 501350/500191

Sri Lanka

1) Ceramic (three factories)

1. Lanka Ceramic Ltd. Negombo Factory
   Thumbowila
   Piliyandara
   Tel. 504215/504211

2. Lanka Walltiles (PVT) Ltd.
   Kirimetitenna,
   Balangoda
   Tel. 045-7295/7228

3. Dankotuwa Porcelain (PVT) Ltd.
   Kurungara Road,
   Dankotuwa
   Tel. 031-7181/7182

2) Cement (one factory)

4. Puttlam Cement Co. Ltd.
   Puttalam,
   Tel.

Appendix 2. Participants List of the Seminar

Appendix 2. Participants List of the Seminar

Bangladesh: 11 May 1994 (Cement Industry)

1.	Mr.Taibur Rahman	Chhattak Cement Co.Ltd.
2.	Mr.Md.Shahjahan	Chhattak Cement Co.Ltd.
3.	Mr.M.A.Quddus	Chhattak Cement Co.Ltd.
4.	Mr.Md.Jahangir Kabir	Chhattak Cement Co.Ltd.
5.	Mr.Md.Golam Morshed	Chhattak Cement Co.Ltd.
6.	Mr.Nazrul Islam	Chhattak Cement Co.Ltd.
7.	Mr.Tarun Kanti Sarker	Chhattak Cement Co.Ltd.
8.	Mr.suleman Ahmed	Chhattak Cement Co.Ltd.
9.	Mr.Hossain Shahid	Chittagong Cement Clinker Grinding Co. Ltd.
10.	Mr.Q.Sahidol Islam	Confidence Cement Ltd.
11.	Mr.S.M.Hasan	Confidence Cement Ltd.
12.	Mr.J.A.Naser	Islam Cement Ltd.
13.	Mr.Yousuf Abdullah	Islam Cement Ltd.
14.	Mr.Abudus Salam	Industrial Consultanting Firm
15.	Mr.Animesh Chandra Shaha	Mongla Cement Factory Ltd.
16.	Mr.Md.Fazlul Huq	Meghna Cement Factory Ltd.
17.	Mr.Habibur Rahman	Meghna Cement Factory Ltd.
18.	Mr.M.A.Khaleq	Sena Kalyan Sangstha
19.	Mr.A.A.M.Rob	Sena Kalyan Sangstha
20.	Engr.Bivash Kumar Paul	Sena Kalyan Sangstha
21.	Mr.Anisur Rahman	Spearhead Engineers
22.	Engr.Shamsuddin Ahmed	Tamali Engineers & Consultant
23.	Mr.Golam Ahmed	Tamali Engineers & Consultant
24.	Dr.Khursheedul Islam	Associated Resoursces Management Co.
25.	Dr.Delwar Hussain	Bangladesh Steel & Engineering Corporation
26.	Mr.M. Rahman Khandker	Electrical Advisor & Chief Electric Inspection
27.	Dr.Rashid	Mechanical Engineering Department, BUET, Dhaka
28.	Dr.M.Serajul Islam	Chemical Engineering Department, BUET, Dhaka
29.	Dr.A.K.M. Bazlur Rashid	Metallurgical Engineering Department, BUET, Dhaka
30.	Dr.M. Nazrul Islam	Institute of Appropriate Technology
31.	Mr.Fuad-ul-Islam	Titas Gas Transmission & Distribution Co.
32.	Engr.Mohammed Hasan	Bakhrabad Gas Systems
33.	Mr.Md.Baziuzzaman	M/O Energy & Mineral Resources
34.	Mr.S.D.Khan	M/O Energy & Mineral Resources
35.	Mr.Dulal Adbul Hafiz	M/O Forest & Environment

36.	Mr.Md.Shahjahan	Department of Environment
37.	Mr.A.B.Bahauddin	Bangladesh Jute Mills Corporation
38.	Engr.Md.Ehsanullah	Bangladesh Oil,Gas & Mineral Corporation
39.	Engr.A.K.M.Azizul Haque	Bangladesh Oil,Gas & MIneral Corporation
40.	Mr.Alamgir Khan Choudhury	Bangladesh Council of Scientific & Industrial Research
41.	Mr.Sanowar Hossain Mondal	Bangladesh Council of Scientific & Industrial Research
42.	mr.Md.Junab Ali	Council of Scientific & Industrial Research
43.	Mr.Md.Mainul Ahsan	Bangladesh Council of Scientific & Industrial Research
44.	Mr.Akhtar Hamid Dewan	Bangladesh Council of Scientific & Industrial Research
45.	Mr.Md.Gullur Rahman Shah	Office of the Chief Inspector of Boiler
46.	Mr.A.Z.M.Sazzadur Rahman	Energy Monitoring & Conservation Centre
47.	Mr.A.F.M.Waliul Islam	Energy Monitoring & Conservation Centre
48.	Mr.Rafiqul Mawla	Energy Monitoring & Conservation Centre
49.	Mr.Md.Mustafizur Rahman	Energy Monitoring & Conservation Centre
50.	Mr.Md.Abdul Haie	Energy Monitoring & Conservation Centre
51.	Mr.S.M.Mahmud Hassan	Energy Monitoring & Conservation Centre
52.	Mr.Sukanta Roy	Energy Monitoring & Conservation Centre
53.	Mr.Md.Mozammel Haque	Energy Monitoring & Conservation Centre
54.	Mr.Md.Rafiqul Islam	Energy Monitoring & Conservation Centre
55.	Mr.Md.Shahabuddin Khan	Energy Monitoring & Conservation Centre
56.	Mr.Md.Nazrul Islam	Energy Monitoring & Conservation Centre
57.	Mr.Q.A.Sharhan Sadique	Energy Monitoring & Conservation Centre
58.	Mr.Kalipada Biswas	Bangladesh Insulator & Sanitaryware Factory
59.	Mr.Badiruddin Ahmed	Bangladesh Institute of Glass & Ceramic
60.	Mr.M.A.Taher	Savar Refractories Ltd.
61.	Mr.A.Hassan Nazemi	UNIDO Vienna, Austria
62.	Mr.G.L.Narasimhan	UNIDO Dhaka
63.	Dr.Juerger Hannak	UNIDO Dhaka

Bangladesh: 12 May 1994 (Ceramic Industry)

1.	Mr.A.E.M.Eshaque	Bangladesh Insulator & Sanitaryware Factory Ltd.
2.	Mr.K.M.Gulzar	Bangladesh Insulator & Sanitaryware Factory Ltd.
3.	Mr.Md.Fazlur Rahman	Bangladesh Insulator & Sanitaryware Factory Ltd.
4.	Mr.S.M.Nazibur Rahman	Bangladesh Insulator & Sanitaryware Factory Ltd.
5.	Mr.Md.Alauddin Shiekh	Bangladesh Insulator & Sanitaryware Factory Ltd.
6.	Mr.Kazi Fazlul Karim	Bangladesh Insulator & Sanitaryware Factory Ltd.
7.	Mr.Giash Uddin Ahmed	Bangladesh Insulator & Sanitaryware Factory Ltd
8.	Mr.Md.Ali Ashraf	Bangladesh Insulator & Sanitaryware Factory Ltd.
9.	Mr.Enamul Wadud Khan	Bengal Fine Ceramics Ltd.
10.	Mr.Mong Sha Hla Marma	Bengal Fine Ceramics Ltd.
11.	Mr.Bayazid Bostami Khan	Bengal Fine Ceramics Ltd.
12.	Mr.Shariyar Masud Khan	Bengal Fine Ceramics Ltd.
13.	Engr.Md.Tasikul Alam	Bengal Fine Ceramics Ltd.
14.	Mr.Nessar Maksud Khan	Bengal Fine Ceramics Ltd.
15.	Mr.Shamsuddin Ahmed	Bengal Ceramic Industries Ltd.
16.	Mr.Kalipada Biswas	Bengal Cemamic Industries Ltd.
17.	Mr.Md.Nasim Ullah Hemaye	Bengal Insulator & Ceramic Industries Ltd.
18.	Mr.Sanwar Hossain Mondal	Bangladesh Ceramic Association
19.	Mr.Alamgir Khan Chowdhur	Bangladesh Ceramic Association
20.	Mr.Quamruzzaman	Bangladesh Chemical Industries Corporation
21.	Mr.A.K.M. Badrul Hossain	Conforce Bricks Ltd.
22.	Mr.Moslehuddin Zaman	Clay Craft Ceramics
23.	Mr.Abdul Hai	Dhaka Ceramics & Sanitary Works Ltd.
24.	Mr.Nasiruddin Hirji	New Dhaka Refractories Ltd.
25.	Mr.Alamgir Khan Choudhur	BCSIR Laboratory
26.	Mr.Sanowar Hossain Monda	BCSIR Laboratory
27.	Mr.Md.Junab Ali	BCSIR Laboratory
28.	Mr.Md.Mainul Ahsan	BCSIR Laboratory
29.	Mr.Akhtar Hamid Dewan	BCSIR Laboratory
30.	Mr.Badiuddin Ahmed	Bangladesh Glass & Ceramic Institute
31.	Mr.Md.Nasiruddin	Bangladesh Glass & Ceramic Institute
32.	Mr.Md.Ashraful Alam	Bangladesh Glass & Ceramic Institute
33.	Mr.Md.Sirajuddin	Bangladesh Glass & Ceramic Institute
34.	Mr.Md.Ayub Ali	Bangladesh Glass & Ceramic Institute
35.	Mr.Abdul Wazed Bhuiya	Monnoo Ceramic Industries Ltd.
36.	Mr.Md.Syed Maniruzzaman	Madhumati Ceramics Ltd.
37.	Mr.Md.Shahjahan Ali Bisw	Mrittika Potteries Ltd.

38.	Mr.Asif Ariff Tabani	Mirpur Ceramic Works Ltd.
39.	Mr.Sakif Arif Tabani	Mirpur Ceramic Works Ltd.
40.	Dr.Md.Abdur Rouf	People's Ceramic Industries Ltd.
41.	Mr.Rafiqul Islam	Reflex Private Ltd.
42.	Mr.Asaduzzaman Khan	Savar Refractories Ltd.
43.	Mr.Rasamoy Boiragy	Savar Refractories Ltd.
44.	Mr.Sardar Elius Sadique	Savar Refractories Ltd.
45.	Mr.Md.Tauhid Hossain	Tajima Ceramic Industries Ltd.
46.	Mr.Md.Sharifuzzaman	Tajima Ceramic Industries Ltd.
47.	Mr.Md.Altaf Hossain	Tajima Ceramic Industries Ltd.
48.	Mr.Md.Abdullah	Jalalabad Gas Transmssion Distribution Co.Ltd.
49.	Mr.Samsuddin Ahmed	Titas Ceramics Ltd.
50.	Mr.Golam Ahmed	Titas Ceramics Ltd.
51.	Dr.Ing. K.Islam	Associated Resources Management Co (ARMCO)
52.	Mr.Md.Jahangir Kabir	Chattak Cement Co.Ltd.
53.	Mr.Md.Abdul Quddus	Chattak Cement Co.Ltd.
54.	Mr.Md.Golam Morshed	Chattak Cement Co.Ltd.
55.	Mr.Nazrul Islam	Chattak Cement Co.Ltd.
56.	Mr.A.Hassan Nazemi	UNIDO Austria
57.	G.L.Narasimhan	UNIDO Dhaka
58.	Dr.Juerger Hannak	UNIDO Dhaka
59.	Eng. Md.Ehsanullah	Bangladesh Oil, Gas & Mineral Corporation
60.	Eng.A.K.M.Azizul Haque	Bangladesh Oil, Gas & MIneral Corporation
61.	Eng.Md.M.Rahman Khandaker	Office of Electrical Adviser & Chief Electrical Insp ctor
62.	Mr.A.Z.M.Sazzadur Rahman	Energy Monitoring & Conservation Centre
63.	Mr.A.F.M.Waliul Islam	Energy Monitoring & Conservation Centre
64.	Mr.Rafiqul Mawla	Energy Monitoring & Conservation Centre
65.	Mr.Md.Mustafizur Rahman	Energy Monitoring & Conservation Centre
66.	Mr.Md.Abdul Haie	Energy Monitoring & Conservation Centre
67.	Mr.S.M.Mahmud Hassan	Energy Monitoring & Conservation Centre
68.	Mr.Sukanta Roy	Energy Monitoring & Conservation Centre
69.	Mr.Md.Mozammel Haque	Energy Monitoring & Conservation Centre
70.	Mr.Md.Rafiqul Islam	Energy Monitoring & Conservation Centre
71.	Mr.Md.Shahabuddin Khan	Energy Monitoring & Conservation Centre
72.	Mr.Md.Nazrul Islam	Energy Monitoring & Conservation Centre
73.	Mr.Q.A.Sharhan Sadique	Energy Monitoring & Conservation Centre

Sri Lanka: 18 May 1994 (Cement Industry)

1.	Mr.K.Abeyguneratne	Puttalm Cement Company Ltd.
2.	Mr.D.M.P.Dharmawansa	Puttalm Cement Company Ltd.
3.	Mr.W.M.Jinadasa	Puttalm Cement Company Ltd.
4.	Mr.R.Shanmugaratnam	Puttalm Cement Company Ltd.
5.	Mr.K.D.Kothalawala	Puttalm Cement Company Ltd.
6.	Mr.K.M.Pathmanathan	Puttalm Cement Company Ltd.
7.	Mr.K.A.I.Karunathilake	Puttalm Cement Company Ltd.
8.	Mr.C.Hettiarachi	Puttalm Cement Company Ltd.
9.	Mr,I.P.Shanthi Kumara	Puttalm Cement Company Ltd.
10.	Mr.P.G.R.Mahanama	Puttalm Cement Company Ltd.
11.	Mr.J.G.Nanayakkara	Puttalm Cement Company Ltd.
12.	Mr.Noel Wijesiriwardene	Lanka Ceramic Ltd.
13.	Mr.D.B.Senerath	Lanka Ceramic Ltd.
14.	Mr.M.U.P>Gunewardene	Ideal Ceramics
15.	Mr.Hemantha Kumara	Hicarb Industrial Carbons (Lanka) Ltd.
16.	Mr.Nihal Kumarasinghe	Lanka Walltiles (Pvt) Ltd.
17.	Mr.Chamath de Silva	Lanka Walltiles (Pvt) Ltd.
18.	Mr.Ranjith Premasiri	International Gift Design (Pvt) Ltd.
19.	Mr.I.S.Zain	Zendec Ceramics
20.	Mr.B.M.G.Bandara	Tokyo Cement Co. (Lanka) Ltd.
21.	Mr.M.M.Jaufer	Tokyo Cement Co. (Lanka) Ltd.
22.	Mr.Sriskanda	Tokyo Cement Co. (Lanka) Ltd.
23.	Mr.M.M.Wickramapala	Ruhunu Cement Co.Ltd.
24.	Mr.M.K.Munidasa	Ruhunu Cement Co.Ltd.
25.	Mr.D.Rupananda	Ruhunu Cement Co.Ltd.
26.	Mr.R.Nihal	Rolanka Ceramics
27.	Mr.A.S.K.Withanage	Industrial Services Bureau
28.	Mr.D.S.R.Dassanayake	Industrial Services Bureau
29.	Dr.Ajith de Alwis	University of Moratuwa
30.	Mr.M.W.Leelaratne	Nerd Centre of Sri Lanka
31.	Mr.K.S.Fernando	Energy Conservation Fund
32.	Mr.D.A.U.Daranagama	Ministry of Energy Conservation
33.	Mr.N.S.R.Siriwardene	Ministry of Energy Conservation
34.	Mr.K.A.U.Ubayathilaka	Ministry of Energy Conservation
35.	Mr.E.W.M.P.Weerasekera	Ministry of Energy Conservation
36.	Mr.W.G.S.Fernando	Ministry of Energy Conservation
37.	Mr.P.P.Subasinghe	Sri Lanka Energy Managers Association

38. Mr.D.V.S.A.Piyatilake Sri Lanka Energy Managers Association

Sri Lanka: 19 May 1994 (Ceramic Industry)

1.	Mr.Noel Wijesiriwardene	Lanka Ceramic Ltd.
2.	Mr.D.B.Senerath	Lanka Ceramic Ltd.
3.	Mr.E.S.K.Soysa	Lanka Ceramic Ltd.
4.	Mr.C.P.Kumarasiri	Lanka Ceramic Ltd.
5.	Mr.U.J.Udawatha	Lanka Ceramic Ltd.
6.	Mr.S.Manage	Lanka Ceramic Ltd.
7.	Mr.Ananda Murhuthanthiri	Lanka Ceramic Ltd.
8.	Mr.N.Thambugala	Lanka Ceramic Ltd.
9.	Mr.P.G.Amarasiri	Lanka Ceramic Ltd.
10.	Mr.J.P.L.Chandralal	Lanka Ceramic Ltd.
11.	Mr.M.U.P>Gunewardene	Ideal Ceramics
12.	Mr.Hemantha Kumara	Hicarb Industrial Carbons (Lanka) Ltd.
13.	Mr.Nihal Kumarasinghe	Lanka Walltiles (Pvt) Ltd.
14.	Mr.Susal Illukkumbura	Lanka Walltiles (Pvt) Ltd.
15.	Mr.Sumith de Silva	Lanka Walltiles (Pvt) Ltd.
16.	Mr.Chamath de Silva	Lanka Walltiles (Pvt) Ltd.
17.	Mr.Ranjith Premasiri	International Gift Design (Pvt) Ltd.
18.	Mr.I.S.Zain	Zendec Ceramics
19.	Mr.U.Weerasinghe	Lanka Tiles Ltd.
20.	Mr.P.D.Piyasena	Lanka Tiles Ltd.
21.	Mr.A.A.H.S.Bandara	Dankotuwa Porcelain (Pvt) Ltd.
22.	Mr.L.F.A.Fernandopulle	Dankotuwa Porcelain (Pvt) Ltd.
23.	Mr.T.Jayantha Fernando	Fernwood Porcelain (Pvt) Ltd.
24.	Mr.Tissa Withanage	G.T.Ceramic üò Tiles (Pvt) Ltd.
25.	Mr.R.Nihal	Rolanka Ceramics
26.	Mr.P.B.Alawathagoda	Noritake Lanka Porcelain (Pvt) Ltd.
27.	Mr.H.A.R.Bandara	Noritake Lanka Porcelain (Pvt) Ltd.
28.	Mr.W.A.R.De Silva	Noritake Lanka Porcelain (Pvt) Ltd.
29.	Mr.A.S.K.Withanage	Industrial Services Bureau
30.	Mr.D.S.R.Dassanayake	Industrial Services Bureau
31.	Dr.Ajith de Alwis	University of Moratuwa
32.	Mr.M.W.Leelaratne	Nerd Centre of Sri Lanka
33.	Mr.K.S.Fernando	Energy Conservation Fund
34.	Mr.D.A.U.Daranagama	Ministry of Energy Conservation
35.	Mr.N.S.R.Siriwardene	Ministry of Energy Conservation
36.	Mr.K.A.U.Ubayathilaka	Ministry of Energy Conservation
37.	Mr.E.W.M.P.Weerasekera	Ministry of Energy Conservation

38.	Mr.W.G.S.Fernando	Ministry of Energy Conservation
40.	Mr.P.P.Subasinghe	Sri Lanka Energy Managers Association
41.	Mr.D.V.S.A.Piyatilake	Sri Lanka Energy Managers Association

Appendix 3. Opening Address of the Chief Guest at the Seminar

Appendix 3. Opening Address of the Chief Guest at the Seminar

SPEECH BY KHANDAKAR MOSHARRAF HOSSAIN
Minister of Energy and Mineral Resources
Bangladesh

AT THE INAUGURATION OF THE ENERGY CONSERVATION SEMINAR
FOR THE CEMENT AND CERAMIC INDUSTRIES - 11TH MAY 1994

Distinguished UNIDO representative, technical experts from Energy Conservation Center, Japan, distinguished invited guests and participants, I am honoured to address today's gathering as the Chief Guest and it is my pleasure to welcome you all.

The level of energy conservation in a country has long been recognized as an economic indicator. In Bangladesh the total energy consumption from all sources is approximately 585 PJ (20.12 Million TCE, tons of coal equivalent) which includes roughly half the quantity in traditional forms. This energy in terms of consumption per capita is very low as compared to most countries. In spite of this low consumption it is also well known that in Bangladesh the energy is not used efficiently. Improvements in energy efficiency are now recognized as central to the pursuit of sustainable strategies for the energy sector. Efforts have now shifted from the traditional way of supply side management to demand side management to cope with the ever increase in energy demands. Bangladesh has been fortunate in having indigenous natural gas resources which presently meets about 65% of the fossil fuel energy demand leaving another 31% in the form of petroleum products being imported causing undue strain on the foreign exchange reserves of the country. However, the darker side of the scenario is that the present reserve of Natural Gas stands at 10.7 TCF and considering a 10% growth in annual demand, this energy source will be available up to year 2010. The global energy scenario is not much different. Energy is a scarce and valuable resource and its efficient use is therefore an area of key concern for all countries.

Energy Conservation and efficiency are areas in which the exchange of technical know-how and experience should receive high priority, particularly in the light of commonalities that exist with regards to features such as structure of industrial sectors and institutional constraints on the implementation of conservation and efficiency measures. Most energy conservation institutions globally were established during the oil crisis periods. The Energy Monitoring & Conservation Center (EMCC) functioning directly under the M/O Energy & Mineral Resources, Govt. of the People's Republic of Bangladesh was established in 1984 with the man objective of promoting energy efficiency, conservation and all related activities.

Following the mid 1980's slump in international petroleum prices the interest of many governments in energy conservation campaigns also tended to decline. However, with the more recent discovery of environmental implications due to the growing fossil fuel consumption the programme of energy conservation and efficiency has received fresh impetus. The overall development objective of this programme is to simultaneously promote economic development and expansion to reduce the rapid growth of fossil fuel consumption and to control the environmental pollution.

Towards this end, United Nations Industrial Development Organization and Energy Conservation Center, Japan in association with the local organization of Energy Monitoring & Conservation Center (EMCC) has organized this seminar on energy conservation technologies in the Cement and Ceramic Industries of Bangladesh. The Cement and Ceramic Industries are by their very nature energy intensive and there exists an vast potentiality for improving energy efficiency in these sectors. It is my firm belief that the participants from these sectors would immensely benefit through their active participation in the day long seminar and interaction with the experts from Japan. I further believe that the knowledge gained herein would be disseminated to appropriate personnel at the factory level and in addition the tangible benefits would be quantified and publicized.

I express my gratitude to UNIDO and the Japanese Government for continued assistance in the developmental activities of Bangladesh in general and in particular for sponsoring this technical seminar in Bangladesh.

With these few words I declare the seminar open and once again thank the distinguished guests, who in spite of their busy schedule, have spared their valuable time to join this session.

SPEECH BY HON. SARATHCHANDRA RAJAKARUNA
(Actg.) Minister of Power & Energy
Minister of Energy Conservation

AT THE INAUGURATION
OF THE ENERGY CONSERVATION SEMINAR
FOR THE CEMENT AND CERAMIC INDUSTRIES - 18TH MAY, 1994.

Hon. Mervyn J. Cooray, State Minister of Power & Energy
Mr. M. Ackiel Mohamed, Secretary, Ministry of Power & Energy
Mr. W.R.B. Rajakaruna, Secretary, Energy Conservation.
Mr. Hassan Nazemi, Representative from UNIDO
Mr. Norio Fukushima, and members of the Japanese Team
from the Energy Conservation Centre, Japan
Mr. Moribe, Resident Representative, JETRO
Mr. Bernabe Gracia, deputy Resident Representative UNDP

Ladies and Gentlemen

It was only three weeks ago that the Ministry of Power & Energy conducted an "ENERGY CONSERVATION WEEK" programme at national level under the distinguished patronage of His Excellency the President.

Activities organised by my staff before, during and after the officially declared week (April 25th tc 30th) have helped to bring the Energy Conservation message very effectively to the Nation. A series of competitions amongst school children, organised on a Island wide scale with the cooperation of the Education Ministry have drawn the attention of the next generation to the Energy and the Environmental problems confronting the Nation and the World and has helped them acquire a basic understanding of the importance and methods of Energy Conservation. A two day programme to check motor vehicles on the roads of Colombo for energy efficiency performance proved to be very successful. Requests to repeat this activity in other large towns are now under consideration. An energy study was carried out in one large Garment Manufacturing Industry to serve as a model to other such factories and the results and recommendations were presented at a seminar to representatives from other factories to that they would be aware of the conservation possibilities in their own.

A major publicity drive was launched to raise the awareness of the general public, through TV, Radio and the press. Over 150000 leaflets in all three languages explaining simple methods of conserving energy in the home, office etc. were distributed. An Exhibition of energy efficient equipment and systems was organised with participation of private and public sector organisations. Public response to this exhibition was much higher than expected.

This demonstrated the public interest on energy conservation and the need for publicity and positive encouragement.

Amongst the other activities undertaken, I would like to recall the pilot project to demonstrate the effect of using energy efficient bulbs. This was done at selected locations in the Parliament Building. I am told that initial measurements reveal an electricity consumption saving of around 70% with light level improvement of about 30%. These are subject to further verification and financial evaluation, but give an indication of the potential for saving and improvement in the field of lighting alone.

The process of activating the end user to conserve energy, or in other words, to use energy wisely, has been going on in this country for more than a decade and has reached a high level through the aaboveactivities. Results have been discernable but will take time to show up at macro level.

Efficiency improvement in the energy supply and distribution systems in the country is the other side of the coin. The two major energy supply authorities, the Ceylon Electricity Board and the Ceylon Petroleum Corporation have taken meaningful steps to raise the overall efficiency of their systems.

More recently the Ceylon Electricity Board has shown interest in Demand Side Management as an effective tool to reduce the annual growth of demand for electricity.

Under this concept, the supply authority will initiate various activities which will directly or indirectly result in the efficient use of electricity. In a similar manner, activities initiated by the Petroleum Corporation will induce efficient use of fuels, especially in the transport and industrial sectors.

These efforts whilst helping the consumer, are also vital from the national point of view. Our most valuable indigenous resource Hydro Electricity has been exploited to a large extent. Harnessing the balance potential is going to be extremely costly. The investments required are beyond financial resources of this country. Eventually such capital investments have to be found from outside and when implemented, will in the long run induce further increases in the electricity rates which are already high enough. In the case of oil too, every additional barrel imported into the country will increase the foreign expenditure burden on the country.

Energy managers all over the world are unanimous in their slogan that a Kilo Watt of Electricity saved and a litre of oil saved is worth more than a newly generated kilo watt of electricity or a new litre of oil sold. Environmentalists will endorse this with even greater emphasis. Conservation of Energy therefore will be a priority concern for all of us, to be vigorously pursued in the future.

Coming to the specific topic of the day, the Cement Industry and the Ceramic Industry are two large scale industries which are heavy users of energy - in the form of oil and electricity. I would also like to mention an allied industry - the Brick and

Tile Industry which uses a large quantity of Firewood - another valuable indigenous energy resource which is being used up fast. According to the information gi.en to me, the Puttalam Cement Factory has used about 62.25 million Kilo Watt Hours of electricity and about 43,450 Metric Tons of fuel oil in 1992. This simply works out to about [illegible] ~~1433~~ Kilo Watt Hours of electricity and about 92 Kilograms of oil per ton of cement.

I am sure our distinguished experts from Japan will show how this energy consumption per ton of production can be reduced.

The Cement Industry is an important primary industry. It provides a basic material required for development work and is also a commodity required extensively by the people for construction and new housing. Improved energy efficiency in the manufacturing process will help to lower the cost payable by the consumer and will also improve the profitability of the producer. Another point about the Cement Industry is that most of the heavy raw material required in its production is available locally. That is one reason why our far sighted National leaders started these industries during the early era of independence. Given the correct impetus, this country could be self sufficient in cement. Improved energy efficiency can help in this process.

The Ceramic Industry in Sri Lanka meets not only local needs, but also exports its products to earn valuable foreign exchange for the country. This Industry too has most of its raw material close at hand. To maintain its export drive it has to compete with other producing countries and in this context, a reduction of energy cost by conservation methods will undoubtedly give the industry a leading edge.

This seminar is therefore timely and I am sure will help the participants to acquire new knowledge which will help them to use energy more effectively in their respective factories. You are going to listen to experts from Japan - a country which has acquired high energy efficiencies in industry through modern technology. When you go back, please make every effort to practice what you learn for the benefit of your organisation as well as the country.

I am thankful to the United Nations Industrial Development Organisation and the Government of Japan for providing the funding for this activity and the Energy Conservation Centre of Japan for sending its experts to conduct this seminar. I thank the organisers for inviting me to be present here today. It has been a pleasure to be here with you at the inauguration.
I wish this seminar success.

Appendix 4. News Release on the Seminar

Need for improvement of energy efficiency stressed

The Financial Express 12 May 94

Minister for Energy and Mineral Resources Khandakar Mosharraf Hossain on Wednesday stressed the need for improvement of energy efficiency for ensuring its optimum use to cope with the ever increasing demand of energy in the country, reports BSS.

Energy conservation, now-a-days, is a universal concern, particularly for Bangladesh and efforts in this area should be relentless, he said.

The energy minister was addressing the inaugural function of a seminar on "energy conservation in cement and ceramic industries" organised jointly by the Ministry of International Trade and Industry (MITI), Japan, United Nations Industrial Development Organisation (UNIDO) and the Energy Conservation Centre (ECC), Japan in collaboration with the local Energy Monitoring and Conservation Centre (EMCC) under the Ministry of Energy and Mineral Resources.

Held at a local hotel the opening ceremony of the two-day seminar was also addressed by Mohammad Faizur Razzaque, Secretary, Ministry of Energy and Mineral Resources and Youshihisa Kuroda, Minister of the Embassy of Japan as special guest, LG Narasimhan, Country Director, UNIDO and Norio Fukushima, team leader of the ECC. Two other members of the ECC team are, Hasashi Ikeda, a cement expert and Motomu Ishikawa, a ceramic expert.

Khandakar Mosharraf Hossain said the total energy consumption from all sources in the country was approximately 585 peta joules (equivalent to 20.12 million tons of coal or 13.525 million tons of oil). The quantity of this energy conservation, he said, was also not efficiently managed.

He said the indigenous natural gas resources presently meet about 65 per cent of the country's fossil fuel demand while about 31 per cent was received from imported petroleum products.

Giving a grim picture of the present known reserve of recoverable natural gas, the energy minister said, its reserve is at 10.7 TCP and at 10 per cent growth in annual demand. This reserve will run out by the year 2010, he pointed out.

The global energy scenario is more or less the same, the minister said adding, therefore, energy conservation is a universal concern.

In all 120 representatives — 60 from cement industries and 60 from ceramic industries — are participating in the two-day seminar.

The energy minister said the seminar would help promote economic development and expansion, reduce the consumption of fossil fuel and control the environments pollution.

He hoped the exchange of technical knowhow and experiences would received high priority in the area of energy conservation and efficiency.

Hossain said the energy monitoring and conservation centre under his ministry was established in 1984 with a view to promoting energy efficiency, conservation and other related activities. Energy conservation institutions were also established globally during the oil crisis period, he added.

The energy minister expressed his firm belief that the participants would immensely be benefitted by taking part in the seminar and interaction with the experts. He hoped the knowledge they acquire would be of real use in their respective cement and ceramic industries which are by their very nature energy intensive.

He thanked the government of Japan and the UNIDO for their continued assistance in the development pursuits of Bangladesh.

Need for optimum use of energy underscored

The Daily Star, 12 May 94

The Minister for Energy and Mineral Resources, Dr Khandakar Mosharraf Hossain, yesterday stressed the need for improvement of energy efficiency for ensuring its optimum use to cope with the ever increasing demand of energy in the country, reports BSS.

Energy conservation, now a days, is a universal concern, particularly for Bangladesh and efforts in this area should be relentless, he said.

The Energy Minister was addressing the inaugural function of a seminar on "energy conservation in cement and ceramic industries" organised jointly by the Ministry of International Trade and Industry (MITI), Japan, United Nations Industrial Development Organisation (UNIDO) and the Energy Conservation Centre (ECC), Japan in collaboration with the local Energy Monitoring and Conservation Centre (EMCC) under the Ministry of Energy and Mineral Resources.

Held at Sonargaon Hotel the opening ceremony of the two-day seminar was also addressed by Mohammad Faizur Razzaque, Secretary, Ministry of Energy and Mineral Resources and Yoshihisa Kuroda, Minister of the Embassy of Japan as special guests, L G Narasimhan, Country Director, UNIDO and Norio Fukushima, team leader of the ECC. Two other members of the ECC team are Hasahi Ikeda, a cement expert and Motomu Ishikawa, a ceramic expert.

Dr Khandakar Mosharraf Hossain said the total energy consumption from all sources in the country was approximately 585 peta jules (equivalent to 20.12 million tons of coal or 13.525 million tons of oil). The quantity of this energy conservation, he said, was also not effciently managed.

He said the indigenous natural gas resources presently meet about 65 per cent of the country's fossil fuel demand while about 31 per cent was received from imported petroleum products.

Improvement of energy efficiency stressed

The Morning Sun 12/5/94

The Minister for Energy and Mineral Resources, Dr Khandakar Mosharraf Hossain, on Wednesday stressed the need for improvement of energy efficiency for ensuring its optimum use to cope with the ever increasing demand of energy in the country, reports BSS.

Energy conservation, now-a-days, is a universal concern, particularly for Bangladesh and efforts in this area should be relentless, he said.

The Energy Minister was addressing the inaugural function at a seminar on "Energy Conservation in Cement and Ceramic Industries" organised jointly by the Ministry of International Trade and Industry (MITI), Japan, United Nations Industrial Development Organisation (UNIDO) and the Energy Conservation Centre (ECC), Japan in collaboration with the local Energy Monitoring and Conservation Centre (EMCC) under the Ministry of Energy and Mineral Resources.

Held at Sonargaon Hotel the opening ceremony of the two-day seminar was also addressed by Mohammad Faizur Razzaque, secretary, Ministry of Energy and Mineral Resources, and Mr Yoshihisa Kuroda, minister, of the Embassy of Japan as special guests. Mr L G Narasimhan, country director, UNIDO and Mr Norio Fukushima, team leader of the ECC. Two other members of the ECC team are Mr Hasashi Ikeda, a cement expert and Mr Motomu Ishikawa, a ceramic expert.

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Earlier Mr Sazzadur Rahman, director, EMCC gave the address of welcome while Mr Mustafizur Rahman gave vote of thanks.

In all one hundred twenty representatives—sixty from cement industries and sixty from ceramic industries—are participating in the two-day seminar.

The Bangladesh Times

Thursday, May 12, 1994

Improvement of energy efficiency stressed

The Minister for Energy and Mineral Resources, Dr Khandakar Mosharraf Hossain, Wednesday stressed the need for improvement of energy efficiency for ensuring its optimum use to cope with the ever increasing demahd of energy in the country, reports BSS.

Energy conservation, now-a-days, is a universal concern, particularly for Bangladesh and efforts in this area should be relentless, he said. The Energy Minister was addressing the inaugural function of a seminar on "energy conservation in cement and ceramic industries" organised jointly by the Ministry of International Trade and Industry (MITI), Japan, United Nations Industrial Development Organisation (UNIDO) and the Energy Conservation Centre (ECC), Japan in collaboration with the local Energy Monitoring and Conservation Centre (EMCC) under the Ministry of Energy and Mineral Resources.

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The Energy Minister said the seminar would help promote simultaneously economic development and expansion, reduce the consumption of fossil fuel and control the environment pollution.

He thanked the Government of Japan and the UNIDO for their continued assistance in the development pursuits of Bangladesh.

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OFFICE OF THE MINISTER OF ENERGY CONSERVATION

MINISTRY OF POWER AND ENERGY

ENERGY CONSERVATION PROGRAMME FOR THE CEMENT AND CERAMIC INDUSTRIES

IT IS NOW CONFIRMED THAT THE ABOVE TRAINING PROGRAMME WILL BE HELD ON 18TH AND 19TH MAY 1994.

NOMINATIONS ALREADY RECEIVED WILL BE VALID FOR THE NEW DATE, AND PARTICIPANTS WILL BE INFORMED OF THE VENUE AND OTHER DETAILS.

CEMENT AND CERAMIC MANUFACTURING ORGANISATIONS WHICH WERE UNABLE TO RESPOND TO THE EARLIER ADVERTISEMENT MAY SEND NOMINATIONS UP TO 5TH MAY 1994, ALONG WITH THE DETAILS CALLED FOR, TO THE ADDRESS BELOW.

SECRETARY – ENERGY CONSERVATION

MINISTRY OF POWER AND ENERGY,
P.O. BOX 576,
COLOMBO 2.

22.04.1994.

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Mr. Mahinda Gamage, Attorney-at-Law (assigned) appeared for the second accused. Daily News

Seminar on May 18–19

19. May

The Ministry of Power & Energy has organised a two day seminar on 'Energy Conservation in the cement and ceramic industries'. The seminar is organised by the Ministry in collaboration with the Energy Conservation Centre of Japan. The seminar will be held on May 18–19 at Amethyst Room, Hilton Hotel, Colombo.

This program is sponsored by United Nations Industrial Development Organization (UNIDO) and the Ministry of International Trade and Industry, Japan (MITI). Mr. Sarathchandra Rajakaruna, acting Minister of Power & Energy will be the chief guest.

programme for homeless

Public lecture

A public lect
'The Political Fu
the Muslims of
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6.30 p.m. today
Main Street, C
11.

The lecture is
ised by the
Forum of the All
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Appendix 5. Seminar Pamphlet

Appendix 5. Seminar Pamphlet

SEMINAR ON ENERGY CONSERVATION
IN
CEMENT AND CERAMIC INDUSTRY

DHAKA, 11 - 12 MAY 1994

AT
THE BALLROOM OF SONARGAON HOTEL

Sponsored by

United Nations
Industrial Development Organization(UNIDO)

and

Ministry of
International Trade and Industry, Japan(MITI)

Organized by

The Energy Conservation Centre, Japan(ECC)

Cooperated by

Energy Monitoring and Conservation Centre(EMCC),
Bangladesh

INTRODUCTION

Energy conservation simply means rational use of energy. It is an effective way of promoting industrialization and advancement in every country in the world. As the international trade competition power becomes stronger, the companies adopting energy conservation can have a competitive edge in the market through lower production cost.

Moreover, the environmental issues such as global warming caused by carbon dioxide emissions from burning fossil fuels and forest destruction by acid rain have now come to receive worldwide attention. To mitigate these adverse environmental effects, energy conservation promotion must be strongly pursued. As the industrialization continues to advance, the precious fossil fuel supply may soon be depleted if nothing is done to curtail energy wastage. Thus, UNIDO and Japan continuously promote assistance and actively support the energy conservation programs in the developing countries.

This Seminar on Energy Conservation in Cement and Ceramic Industry is one of such activities which UNIDO and ECC, Japan have organized in cooperation with the Ministry of Energy & Mineral Resources, Government of Bangladesh, to contribute to the development of the nation's human resources and economy.

OBJECTIVE

The objective of the seminar is to promote energy conservation and thereby to accelerate technology transfer in the cement and ceramic industries of Bangladesh through lecture, discussion and the use of reference manuals.

RESOURCE PERSONS

The following resource persons from Japan will conduct the seminar:

Mr. Hisashi IKEDA (Cement Expert)
Technical Advisor,
The Energy Conservation Center, Japan

Motomu ISHIKAWA (Ceramic Expert)
Technical Advisor,
The Energy Conservation Center, Japan

PROGRAM

<u>1st Day, 11 May 1994(Wed)</u>

8:30 - 9:30	Registration of Participants
9:30 - 10:30	Opening Ceremony
10:30 - 11:00	Tea Break
11:00 - 12:30	Energy Conservation in Cement Industry(I)
12:30 - 13:30	Lunch and Prayer
13:30 - 15:00	Energy Conservation in Cement Industry(II)
15:00 - 15:30	Tea Break
15:30 - 17:00	Discussion

<u>2nd Day, 12 May 1994(Thu)</u>

8:30 - 9:30	Registration of Participants
9:30 - 11:00	Energy Conservation in Ceramic Industry(I)
11:00 - 11:30	Tea Break
11:30 - 13:00	Energy Conservation in Ceramic Industry(II)
13:00 - 14:00	Lunch and Prayer
14:00 - 15:30	Discussion
15:30 - 16:00	Tea Break
16:00 - 17:00	Explanation on the Use of Energy Audit Equipment
17:00	Closing

REGISTRATION FORM

Please tick your choice of attendance from the following :

1. First Day (Cement Industry)

2. Second Day (Ceramic Industry)

Full Name :
(in block letter)

Job Title/Position :

Organization :

Office Address with Phone No.

Note : 1) This registration form has to be sent to the following address by 5 May 1994(Thu):

The Director,
Energy Monitoring & Conservation Centre,
(Ministry of Energy & Mineral Resources)
House-741, Road-9, Baitul Aman Housing Society,
Adabor, Shyamoli, Dhaka-1207

(Attn : Engr. Md. Mustafizur Rahman, Energy Auditor
Tel : 315961, 319228)

2) No TA/DA Will be provided by the Organizers to any participant.

সেমিনার অন ইউজ অফ এনার্জি সেভিং টেকনোলজী ইন সিরামিক এণ্ড সিমেন্ট ইণ্ডাষ্ট্রি

উদ্বোধনী অনুষ্ঠান

২৮শে বৈশাখ, ১৪০১ □ ১১ ই মে, ১৯৯৪

At the Ballroom of Sonargaon Hotel on 11 May 1994(Wed)

PROGRAM

09:25	Guests and Participants to be seated
09:30	Arrival of the Chief Guest and the Special Guest
09:31	Recitation from the Holy Quran
09:35	Welcome Address by the Director of EMCC Bangladesh (Mr. A.Z.M. Sazzadur Rahman)
09:40	Address of the Team Leader, ECC Japan (Mr. Norio Fukushima)
09:45	Address of the Country Director, UNIDO Dhaka (Mr. G.L. Narasimhan)
09:55	Address of the Special Guest (Mr. Y. Kuroda, Minister, Embassy of Japan in Dhaka)
10:00	Address of the Special Guest (Mr. Muhammad Faizur Razzak, Secretary, Ministry of Energy & Mineral Resources, Govt. of Bangladesh)
10:10	Address of the Chief Guest (Dr. Khondaker Mosharraf Hossain, Minister of Energy & Mineral Resources, Govt. of Bangladesh)
10:20	Vote of Thanks (Mr. Md. Mustafizur Rahman, EMCC Bangladesh)
10:25	Tea

অনুষ্ঠান সূচী

সময়		অনুষ্ঠান
৯-২৫ মিঃ	ঃ	অতিথিবৃন্দের আসন গ্রহণ।
৯-৩০ মিঃ	ঃ	প্রধান অতিথি ও বিশেষ অতিথিদের আগমন।
৯-৩১ মিঃ	ঃ	পবিত্র কোরআন শরীফ থেকে তেলাওয়াত।
৯-৩৫ মিঃ	ঃ	স্বাগত ভাষণ- পরিচালক, ইএমসিসি, ঢাকা।
৯-৪০ মিঃ	ঃ	ভাষণ- টীম লীডার, ইসিসি, জাপান।
৯-৪৫ মিঃ	ঃ	ভাষণ- কান্ট্রি ডাইরেক্টর, ইউনিডো, ঢাকা।
৯-৫৫ মিঃ	ঃ	ভাষণ- বিশেষ অতিথি, জনাব ওয়াই কুরুদা, মিনিষ্টার, জাপান দূতাবাস, ঢাকা।
১০-০০ মিঃ	ঃ	ভাষণ- বিশেষ অতিথি, জনাব মুহাম্মদ ফয়জুর রাজ্জাক, সচিব, বিদ্যুৎ, জ্বালানি ও খনিজ সম্পদ মন্ত্রণালয়।
১০-১০ মিঃ	ঃ	ভাষণ- প্রধান অতিথি, ডঃ খন্দকার মোশাররফ হোসেন, মাননীয় মন্ত্রী, বিদ্যুৎ, জ্বালানি ও খনিজ সম্পদ মন্ত্রণালয়।
১০-২০ মিঃ	ঃ	ধন্যবাদ জ্ঞাপন- জনাব মোঃ মোস্তাফিজুর রহমান, এনার্জি মনিটরিং এণ্ড কনজারভেশন সেন্টার, ঢাকা।

স্থান- বলরুম, হোটেল সোনারগাঁও, ঢাকা।

তারিখ- ১১ ই মে, ১৯৯৪ সাল

সুধী,

আগামী ১১-১২ ই মে'৯৪ তারিখে ইউনিডো-ইসিসি জাপান এর যৌথ উদ্যোগে এবং বিদ্যুৎ, জ্বালানি ও খনিজ সম্পদ মন্ত্রনালয়ের এনার্জি মনিটরিং এণ্ড কনজারভেশন সেন্টারের সহযোগিতায় সিরামিক ও সিমেন্ট শিল্পে জ্বালানির দক্ষ ব্যবহার, সাশ্রয় ও সংরক্ষণ এর উদ্দেশ্যে **"এনার্জি সেভিং টেকনোলজি ইন সিমেন্ট এণ্ড সিরামিক ইণ্ডাষ্ট্রি"** শীর্ষক একটি সেমিনার অনুষ্ঠিত হইবে।

গণপ্রজাতন্ত্রী বাংলাদেশ সরকারের বিদ্যুৎ, জ্বালানি ও খনিজ সম্পদ মন্ত্রনালয়ের দায়িত্বে নিয়োজিত মাননীয় মন্ত্রী ডঃ খন্দকার মোশাররফ হোসেন উক্ত সেমিনারটি উদ্বোধন করিতে সদয় সম্মতি জ্ঞাপন করিয়াছেন।

জনাব মুহাম্মদ ফয়জুর রাজ্জাক, সচিব, বিদ্যুৎ, জ্বালানি ও খনিজ সম্পদ মন্ত্রনালয় এবং জনাব ওয়াই কুরুদা, মিনিষ্টার, জাপান দূতাবাস, ঢাকা- উক্ত অনুষ্ঠানে বিশেষ অতিথি হিসাবে উপস্থিত থাকিবেন।

উক্ত উদ্বোধনী অনুষ্ঠানে আপনাকে সানুগ্রহ আমন্ত্রন জানাইতেছি।

অপারগতায়ঃ
৩১৯২২৮/৩১৫৯৬১

পরিচালক
এনার্জি মনিটরিং এণ্ড কনজারভেশন সেন্টার

অনুগ্রহ করে আমন্ত্রনপত্র সঙ্গে আনিবেন।

SEMINAR PROGRAMME
(tentative)

FIRST DAY - Wednesday 18th May 1994

8.30 am - 9.00 am	-	Registration
9.00 am - 9.30 am	-	Inauguration Ceremony
9.30 am - 10.00 am	-	Tea Break

(The distinguished invitees will leave after tea)

10.00 am - 11.30 am	-	LECTURE Energy Conservation in the Cement Industry
11.30 am - 12.30 pm	-	Questions and discussions
12.30 pm - 1.30 pm	-	Lunch Break
1.30 pm - 3.00 pm	-	LECTURE Energy Conservation in the Cement Industry
3.00 pm - 3.30 pm	-	Tea Break
3.30 pm - 4.30 pm	-	Questions and discussions

SECOND DAY - Thursday 19th May 1994

9.00 am - 9.15 am	-	Registration
9.15 am - 10.30 am	-	LECTURE Energy Conservation in the Ceramic Industry
10.30 am - 11.00 am	-	Tea Break
11.00 am - 12.30 pm	-	LECTURE Energy Conservation in the Ceramic Industry
12.30 pm - 1.30 pm	-	Lunch
1.30 pm - 3.00 pm	-	LECTURE
3.00 pm - 3.30 pm	-	Tea Break
3.30 pm - 4.30 pm	-	Discussion and Closing Session

SEMINAR
ON
ENERGY CONSERVATION
IN THE
CEMENT AND CERAMIC INDUSTRIES

18TH and 19TH MAY 1994

at the

"AMETHYST ROOM"
HILTON HOTEL
COLOMBO

Sponsored By
UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANISATION
(UNIDO)

and

MINISTRY OF
INTERNATIONAL TRADE AND INDUSTRY JAPAN
(MITI)

Organised By
THE ENERGY CONSERVATION CENTRE, JAPAN
IN COLLABORATION WITH
THE OFFICE OF THE
MINISTER OF ENERGY CONSERVATION
MINISTRY OF POWER AND ENERGY
SRI LANKA.

INTRODUCTION

Energy is a vital and expensive input to industry. In many industries, it accounts for a sizeable proportion of the total production cost.

Energy Conservation, or the rational use of energy, helps to reduce production cost and thereby improves profitability and competetiveness in industrial and commercial organisations. In the national context, it promotes effective use of scarce energy resources and assists the national effort towards industrialisation and economic and social advancement in developing countries.

Conservation of energy also helps to mitigate adverse effects on the environment caused by the uncontrolled production and use of energy.

THE ROLE OF UNIDO AND JAPAN IN PROMOTING ENERGY CONSERVATION.

The United Nations Industrial Development Organisation and the government of Japan have provided assistance and active support to promote energy conservation programmes in developing countries.

The forth coming Seminar on Energy Conservation in the Cement and Ceramic Industries is one such activity organised by UNIDO and the Energy Conservation Centre, Japan in collaboration with the Office of the Minister of Energy Conservation, Ministry of Power and Energy, Sri Lanka.

THE OBJECTIVE

To Promote energy Conservation by transfer of technology related to energy efficiency improvement, specifically in the Cement and Ceramic Industries, through lectures, discussions and supplementary reference manuals.

THE TARGET GROUP

Engineers, senior managers, middle level operating and production staff and energy managers particularly in the Cement and Ceramic industries. The Seminar will be conducted in English by Japanese Experts.

PARTICIPATION

All prospective participants are requested to complete the enclosed registration card and return same to the undersigned BEFORE **10th May, 1994**, even though their respective organisations have nominated them earlier. Organisations nominating more than one participant may return all cards under one cover.

NO COURSE FEE WILL BE CHARGED.

However all participants will have to make their own arrangements for travel and overnight accommodation. Such costs <u>will not</u> be met by the sponsors.

PLEASE RETURN THE REGISTRATION CARD AND ADDRESS ANY FURTHER INQUIRIES TO:-

G. T. Fernando
Director - Energy (D&I)
Office of the Minister of Energy Conservation
Ministry of Power & Energy,
P.O. Box 576, Colombo.
Tel: 449289 Fax: 422065

SEMINAR ON ENERGY CONSERVATION

IN THE

CEMENT AND CERAMIC INDUSTRIES

PROGRAMME FOR THE INAUGURAL SESSION

18TH MAY 1994

"AMETHYST ROOM", HILTON HOTEL, COLOMBO

8.50 a.m.	Arrival of Invitees
8.55 a.m.	Arrival of Chief Guest
9.00 a.m.	Lighting of Traditional Oil Lamp
9.05 a.m.	Welcome Address by Mr.W.R.B.Rajakaruna, Secretary, Energy Conservation Ministry of Power & Energy
9.10 a.m.	Address by Mr.Norio Fukushima, Leader of Japanese Panel of Lecturers
9.15 a.m.	Address by Chief Guest, Hon.Sarathchandra Rajakaruna, Minister of Energy Conservation
9.25 a.m.	Vote of Thanks by Mr.G.T.Fernando, Director Energy (D&I), Ministry of Power & Energy
9.30 a.m.	Tea

The Secretary
to the
MINISTER OF ENERGY CONSERVATION

cordially invites

to be present at the

INAUGURAL SESSION
of the

SEMINAR ON ENERGY CONSERVATION
IN THE
CEMENT AND CERAMIC INDUSTRIES

sponsored by
UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANISATION
(UNIDO)

and

MINISTRY OF
INTERNATIONAL TRADE AND INDUSTRY JAPAN
(MITI)
and organised by the

THE ENERGY CONSERVATION CENTRE, JAPAN

in collaboration with the

OFFICE OF THE MINISTER OF ENERGY CONSERVATION
MINISTRY OF POWER AND ENERGY
on 18th May 1994 from 9.00 am. to 10.00 a.m.
at the

" AMETHYST ROOM"
HOTEL HILTON COLOMBO

with
HON.SARATHCHANDRA RAJAKARUNA
MINISTER OF ENERGY CONSERVATION
as Chief Guest

Appendix 6. Terms of Reference

Appendix 6. Terms of Reference

17 November 1993

**PROGRAMME ON USE OF ENERGY-SAVING TECHNOLOGIES
IN CERAMIC AND CEMENT INDUSTRIES**

US/RAS/93/039

**TERMS OF REFERENCE
FOR SUBCONTRACTING ORGANIZATION**

I. Project objective

To increase the awareness and knowledge of government officials and industrial users on appropriate energy-saving technologies in the Ceramic and Cement Industries in Sri Lanka and Bangladesh.

II. Background information

The current pattern of energy utilization in developing countries is not sustainable, since the excessive use of energy is one of the characteristics of many industrial plants in these countries. Therefore, it is necessary to introduce and disseminate information about modern appropriate energy conservation/saving technologies among the parties concerned in governments and especially, at plant-level in industries in developing countries.

In December 1983, UNIDO organized a Regional Meeting on Energy Consumption in Small and Medium Industries and an Expert Group Meeting on Exchange of Experiences on Energy Conservation in Small and Medium Industries for Asian countries. During the meeting, it was revealed by some countries that for several energy-intensive industries (e.g. iron and steel, pulp and paper, glass, cement and ceramic, and chemical industries), a saving of up to 10% on the energy consumption could be achieved through basic house-keeping improvements in terms of auditing and energy management. Larger savings could be achieved (up to 30% in a period of about 2-3 years) through the application of energy-saving technologies by retrofitting, installation of control mechanisms and simple process changes.

The Fourth General Conference of UNIDO, held in August 1984, advocated UNIDO's assistance to developing countries in their effort to achieve rational use of energy in industry and in obtaining energy from new and renewable sources. To achieve environmentally sound industrialization for developing countries, UNIDO is now being strongly called upon to systematically integrate energy-management and energy-saving components into technical cooperation projects.

In 1990, UNIDO started a new programme on the Rational Use of Energy-Saving Technologies and, in 1991, a first project - US/RAS/90/075 "Programme for Rational Use of Energy in Iron and Steel and Textile Industry" - was approved, financed by the Government of Japan. In-plant surveys, seminars and demonstration of factory audits on the application of appropriate technologies for the effective use of energy were conducted by Japanese and UNIDO specialists in Malaysia and Indonesia. As a result of this programme, a Handy Manual to provide guidelines on Energy-Saving Technologies for Iron and Steel and Textile Industries has been prepared. The manuals, currently available in English, are in process of translation into French and Spanish in order to be disseminated to other developing countries in Asia, Africa and Latin America.

The success of this promotional activity prompted UNIDO to request the support of the Government of Japan to carry out a similar project under this Programme. A second project was approved for the Rational Use of Energy-Saving Technologies in Pulp and Paper and Glass Industries in the Philippines and Thailand, where many of the above-mentioned industries were found, and human resources as well as technological levels were adequate for applying energy conservation technologies. In addition UNIDO was providing some assistance in the area of energy management. Also, strong counterpart institutions were available. Surveys were carried out and the seminars and demonstration through factory audits were carried out in February 1993. Also, handy manuals for energy-saving technologies in the pulp/paper and glass industries have been prepared and will be widely disseminated in three languages.

After these two experiences and after an assessment done by UNIDO and the Japanese counterpart on the excellent results and multiplier effects of this programme in developing countries, it was agreed, in principle, to submit a new project for the Rational Use of Energy-Saving Technologies in Ceramic and Cement Industries in Sri Lanka and Bangladesh. There exists quite a good number of industries in these industrial sectors in both countries, but still the aspect of conservation of energy is in some way neglected, much energy is wasted and it is necessary to assist them to utilize appropriate techniques to avoid this. This is the reason why UNIDO has selected these two industrial branches in the two countries for our next project. Also, a strong and adequate counterpart has been identified and human resources as well as technological levels are adequate for introducing energy conservation technologies. (Refer to Annex IV of the project document for background information on the counterpart organizations and on the situation of ceramic and cement industries in Sri Lanka and Bangladesh).

The experience obtained through this project will be applied to other programme/projects which involve more countries (regions) through the publication of the handy manuals on the energy-saving technologies.

Under this regional programme, Sri Lanka and Bangladesh as well as other developing countries will benefit at the end of the project from UNIDO's experience in promoting and applying energy-saving technologies in the ceramic and cement industries, with a multiplier effect in the industrial and technology process development as well as in the environment conservation in these countries. It is expected that under the same programme several other industrial sectors e.g. food, wooden industries and other chemical industries will be taken up in future activities.

III. Scope of contracting service

A. The subcontractor is expected to carry out, during a period of 3 weeks, field surveys at plant level in Sri Lanka and Bangladesh in the ceramic and cement industries in order to define the various factors of excessive energy consumption and inefficient energy utilization. With the support of government and local counterparts in both countries, the subcontractor should select the plants listed in Annex I, which are presently energy intensive and could expect considerable improvements in their energy consumption. The surveys should include a detailed analysis of the type of Kilns used in the country and a comparative analysis of their energy efficiency; a review of the environmental aspects of the industries in relation to the choice and availability of energy sources and raw materials in the country and a diagnostic on the current batch compositions by taking into account the locally available raw materials. The results of these observations will be utilized for the preparation of the draft manual and demonstrated during the implementation of the seminars.

B. In close cooperation with the Directorate of Energy, Ministry of Energy Conservation of Sri Lanka and the Energy Monitoring and Conservation Centre, Ministry of Energy and Mineral Resources of Bangladesh, two-days' seminars will be held in each country for top executives, middle level managers, government officials, engineers and technicians, and people responsible for the production process and policies regarding energy-saving aspects in the concerned industries of the two countries. The above-mentioned two government organizations have expressed their willingness to support this programme and provide, in particular, assistance for the implementation of the seminars in their countries. The seminar lecturers will come from the subcontracted organization, from the counterparts in Sri Lanka and Bangladesh as well as from UNIDO HQ.

C. The subcontractor will also carry out, during the seminar days in Sri Lanka and Bangladesh, an ex-post survey of the selected plants in order to assess the implementation and results of the application of the recommendations contained in the draft manuals.

D. UNIDO expects that the subcontractor prepares 600 copies each of the handy manuals in English on energy conservation/saving technologies in ceramic and cement industries, for the use of technical operators in improving energy efficiency practices at the plant level in developing countries. The two handy manuals will describe the selected energy conservation subjects according to the following frameworks:

Manual 1 - Ceramic

- Character of manual
- Characteristics of Energy Consumption
    - Manufacturing Process and Main Facilities:
        - Detailed analysis of all stages of manufacturing process with specific focus on the performance of ceramic kilns etc.
    - Situation of Energy Consumption:
        - Description of state-of-the-art of energy saving schemes in ceramic industry with specific focus on newly emerging kiln technologies.
    - Rational Use of Energy:
        - Introduction of improved insulation and heat recovery systems.
        - Refractory applications in the ceramic industry and an analysis of related operational problems.

- Introduction of practical energy auditing techniques and energy efficiency analysis.
- Energy-saving possibilities through selection of raw materials.
- Kiln-firing systems and firing techniques and introduction of corrective measures and/or technologies.

Manual 2 - Cement

- Character of Manual
- Characteristics of Energy Consumption
  - Production of Processes and Main Equipment
  - Situation of Energy Consumption
  - Kilns process
  - Dust removal
  - Drying
- Rational Use of Energy
  - Rationalization of Fuel Combustion
  - Waste heat recovery
  - Improvement of operation control
  - Improvement of production process

The handy manuals will demonstrate innovative energy conservation/saving technologies developed in Japan and adapted to the conditions and requirements of the ceramic and cement industries in developing countries. All analysis and recommendations given are based on existing and available technological solutions and resources. The suppliers of technology and sources of information must clearly be indicated. During the preparation of the handy manuals, information available on UNIDO's expertise and experience in promoting energy conservation/saving technologies in developing countries as well as those available in Japan will be reviewed by the subcontractor and incorporated into the proposed technical manuals.

The two technical handy manuals should be prepared in English language. Three copies of the draft handy manuals will be submitted to UNIDO by the subcontractor for comments before final printing. 600 copies of each of the two technical handy manuals will be required to be forwarded to UNIDO HQ for distribution in developing countries. The two handy manuals will be prepared very clearly and in a simple style in order to have a practical application by the users.

E. A final report which summarizes all work done, including the outputs of the seminars held in Sri Lanka and Bangladesh, as well as recommendations and conclusions for follow-up actions in dissemination of energy-conservation technologies among developing countries will be prepared by the subcontractor. 3 copies of the draft final report in English shall be submitted to UNIDO HQ for comments. The final version of this report should be prepared in 10 copies and forwarded to UNIDO HQ.

F. The subcontractor will provide the following personnel to carry out the scheduled project activities:

- 3 experts (a team leader, a Cement expert and a Ceramic expert) for 3 weeks, to implement plant observations in Sri Lanka and Bangladesh including supervision of the local counterparts.

- A Cement expert and a Ceramic expert for 2 weeks, to organize seminars and hold lectures as well as to take care of the dissemination of the technical manuals in Sri Lanka and Bangladesh and to carry out an ex-post survey of the selected plants to assess the implementation and results of energy conservation measures recommended by the subcontractor team.

During the preparation and implementation of all these activities, national experiences and expertise of the two countries on the application of energy conservation/saving technologies shall be involved and presented during the seminars.

G. The subcontracting organization will be fully responsible for the provision of all necessary facilities and services to conduct the scheduled seminars in Sri Lanka and Bangladesh for 2 days each and for about 50 participants of each (ceramic and cement industries) seminar.

In particular the following facilities will be provided by the subcontractor:

- Seminar registration desks and receptions

- Simultaneous interpretation services (English, Japanese and national language)

- Microphones

- Audio-visual equipments, projector, movie screen, video-tape players, tape recorder, etc.

- Podium for lectures

- Miscellaneous services

The local counterparts in Sri Lanka and Bangladesh shall assist the subcontractor in the provision of the above-mentioned facilities, but at no cost to them.

H. The subcontracting organization shall plan the activities falling under the scope of the subcontracting service in accordance with the Tentative Work Plan at Annex II.

IV. Evaluation

The project shall be subject to evaluation in accordance with the policies and procedures established for this purpose by UNIDO. Follow-up activities will be undertaken by each country's government authorities and enterprises.

KaV/toreccj

ANNEX I

LIST OF CERAMIC AND CEMENT INDUSTRIES IN SRI LANKA AND BANGLADESH

A. SRI LANKA - Ceramic Industries

1. Lanka Ceramics Ltd. - Piliyandala Factory
2. " " " - Negombo Factory
3. Dankotuwa Porcelain Ltd. - Dankotuwa
4. Ceramic World Ltd. - Biyagama
5. Lanka Porcelain Ltd.
6. Lanka Walltiles Ltd.
7. Boralesgamuwa Ceramic Factory Ltd.
8. Meetiyagoda Ceramic Factory Ltd.
9. Dediytawela Ceramic Factory Ltd.
10. Hungama Ceramic Factory Ltd.
11. Lanka Tiles Ltd.

B. SRI LANKA - Cement Industries

1. Ceylon Cement Corporation - Puttlam Cement Factory
2. " " " - Galle Cement Factory
3. Clinker Processing Factory - Trincomallee

C. BANGLADESH - Ceramic Industries

1. Mono Ceramics Ltd.
2. Bangali Fine Ceramics Ltd.
3. B.C.I.C - Tiles, Sanitary wares and Insulators Factories

D. BANGLADESH - Cement Industries

1. Bangladesh Chemical Industry Corporation - Chattak Cement factory
2. Chittagong Clinker Factory
3. Khulna Clinker Factory

Annex II

Tentative Workplan

Project US/RAS/93/039

Activities	1st month	2nd month	3rd month	4th month	5th month	6th month	7th month	8th month	9th month
Award of Contract	—								
Field Survey (Sri Lanka, Bangladesh)		—							
Preparation of Manuals:									
- Manuscript in Japanese			—	—					
- English Translation					—				
- Submission and Approval of draft Manuals by UNIDO						—			
Final approval								—	
Preparation/ finalization of Seminars' Programmes	—	—	—	—	—	—	—		
Printing of Manuals								—	
Preparation of Seminars					—	—			
Advertising of the Seminars						—	—		
Holding Seminars (2 days each place + UNIDO staff mission)							—		
Preparation of a Report								—	—

Appendix 7. Textbooks of the Seminar

HANDY MANUAL

CERAMIC INDUSTRY

Output of a Seminar on Energy Conservation in Ceramic Industry

Sponsored by

United Nations Industrial Development Organization (UNIDO)

and

Ministry of International Trade and Industry (MITI), Japan

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PREFACE

The conservation of energy is an essential step we can all take towards overcoming the mounting problems of the worldwide energy crisis and environmental degradation. In particular, developing countries are interested to increase their awareness on the inefficient power generation and energy usage in their countries. However, usually only limited information sources on the rational use of energy are available.

The know-how on modern energy saving and conservation technologies should, therefore, be disseminated to government and industrial managers, as well as to engineers and operators at the plant level in developing countries. It is particularly important that they acquire practical knowledge of the currently available energy conservation technologies and techniques.

In December 1983, UNIDO organized a Regional Meeting on Energy Consumption as well as an Expert Group Meeting on Energy Conservation in small- and medium-scale industries for Asian countries. During these meetings, it was brought out that, for some energy intensive industries, savings up to 10% could be achieved through basic housekeeping activities, such as auditing and energy management.

All these experiences brought UNIDO to prepare a regional programme on the promotion and application of energy saving technologies in selected subsectors, since the rational use of energy calls for a broad application of energy conservation technologies in the various industrial sectors where energy is wasted. One of these energy intensive industrial sectors to be considered to improve efficiency through the introduction of modern energy conservation technologies is the ceramic industry.

The ceramic industry consumes much energy. The ceramic industry is also noted for great percentage of the energy cost in the total production cost.

In the ceramic industry, appreciable amounts of energy could be saved or conserved by preventing of leakage in the kilns and controlling of combustion, modifying the equipment to recover heat from the kiln in the process of ceramic-firing.

Currently, UNIDO is implementing this programme with the financial support of the Japanese Government, in selected Asian developing countries. This programme aims at adapting these innovative energy conservation technologies, developed in Japan, to the conditions of developing countries.

In this programme, we are considering that the transfer of these technologies could be achieved through:

(i) Conducting surveys of energy usage and efficiency at the plant level;

(ii) Preparing handy manuals on energy management and energy conservation/saving technologies, based on the findings of the above survey;

(iii) Presenting and discussing the handy manuals at seminars held for government officials, representatives of industries, plant managers and engineers;

(iv) Disseminating the handy manuals to other developing countries for their proper utilization and application by the industrial sector.

The experience obtained through this programme will be applied to other programmes/projects which involve other industrial sectors as well as other developing countries and regions.

UNIDO has started this programme with the project US/RAS/90/075 - Rational Use of Energy Resources in Steel and Textile Industry in Malaysia and Indonesia and the project US/RAS/92/035 - Rational Use of Energy Saving Technologies in Pulp/Paper and Glass Industry in Philippines and Thailand. These were followed by project US/RAS/93/039 Program for the Use of Energy Saving Technologies in the Ceramic and Cement Industries in Sri Lanka and Bangladesh.

The present Handy Manual on Ceramic Industry was prepared by UNIDO, with the cooperation of experts from the Energy Conservation Center (ECC) of Japan, on energy saving technologies in the framework of the above-mentioned UNIDO project. It is based on the results of the surveys carried out, the plant observations and the recommendations and suggestions emanating from the Seminars on Energy Conservation in the Ceramic Industry, held under the same project in May 1994 in Dhaka, Bangladesh and Colombo, Sri Lanka respectively. The handy manual will not only be interesting for government and representatives from industry, but it is, in particular, designed for plant-level engineers and operators in developing countries as a tool to improve energy efficiency in the production process.

Appreciation is expressed for the valuable contribution made by the following institutions to the successful preparation and publication of the manual mentioned above:

Ministry of Energy and Mineral Resources, Bangladesh

Ministry of Power and Energy, Sri Lanka

Ministry of International Trade and Industry (MITI), Japan

The Energy Conservation Center (ECC), Japan

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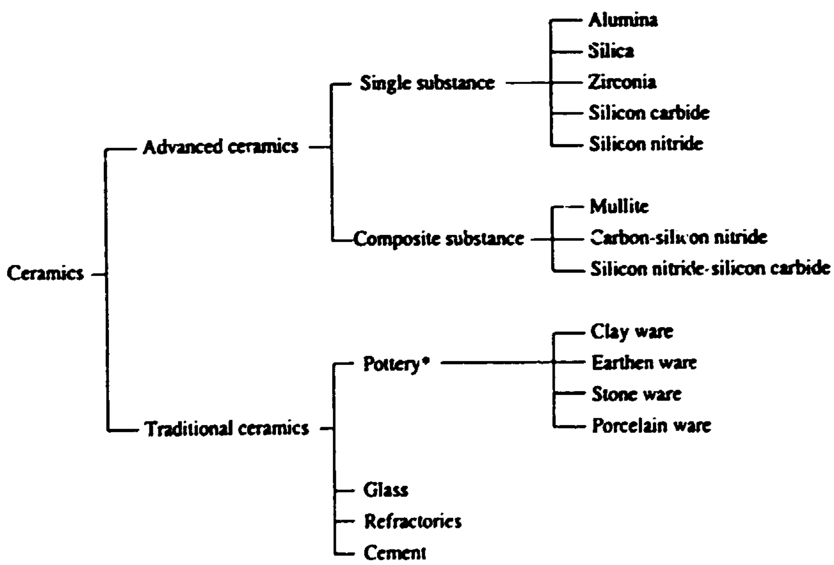
1. Manufacturing process of ceramics

Naturally occurring inorganic substances are heat-treated after adjustment of the grain size and moisture, and some of them are completely molten to be formed into ceramics; while others are formed, heat-treated and made into the ceramic products in the sintered state immediately before being molten. The former product formed in the molten state is known as glass, and the latter product finished in the sintered state includes pottery, refractories, sanitary ware, tiles and cement. These ceramics are called traditional ceramics. By contrast, extremely fine particles of high-purity inorganic substances such as alumina (Al_2O_3), silica (SiO_2), zirconia (ZrO_2) and silicon nitride (Si_3N_4) are sintered at a high temperature and made into ceramics; they are called advanced ceramics. These advanced ceramics are used in electronic parts and mechanical parts. The following describes the traditional ceramics production process:

1.1 Classification of ceramics

Ceramics can be classified in many ways; Table 1 shows one of the classifications and Fig. 1 illustrates the classification of the pottery.

Table 1 Classification of ceramics



* Clay ware: Clay ware is produced by firing the clay material at a low temperature (1050°C) after the water of crystallization has been dehydrated. It includes tiles and flowerpots.

Earthen ware : The earthen ware is produced by firing in the shrinking period of the crystallization process of new crystals (mullite, cristobalite by solid reaction, etc.), and the firing temperature is from 1050 to 1150°C.

Stone ware : Stone ware is produced by firing at the maximum density (1150 to 1250°C) in the advanced glassification process.

Porcelain : Porcelain is produced by firing (at the temperature of 1250°C or more) until the product becomes translucent with an increase in glass phase.

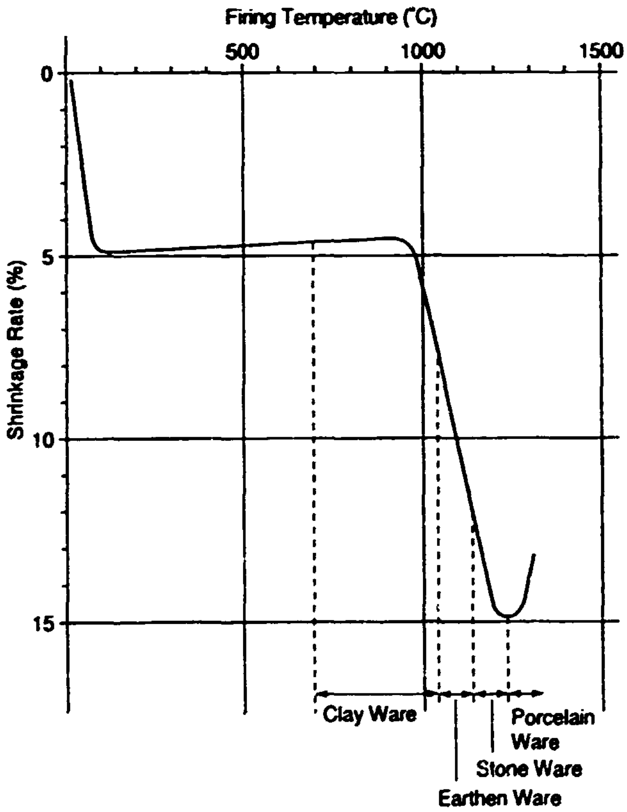


Figure 1 Classification of the pottery and shrinkage rate

1.2 Manufacturing process of ceramics

The following describes the recent production process of traditional ceramics.

The basic production process of traditional ceramics is shown below:

Raw material → crushing and secondary crushing → blending → pulverization and kneading → forming → drying → firing → processing and shipment

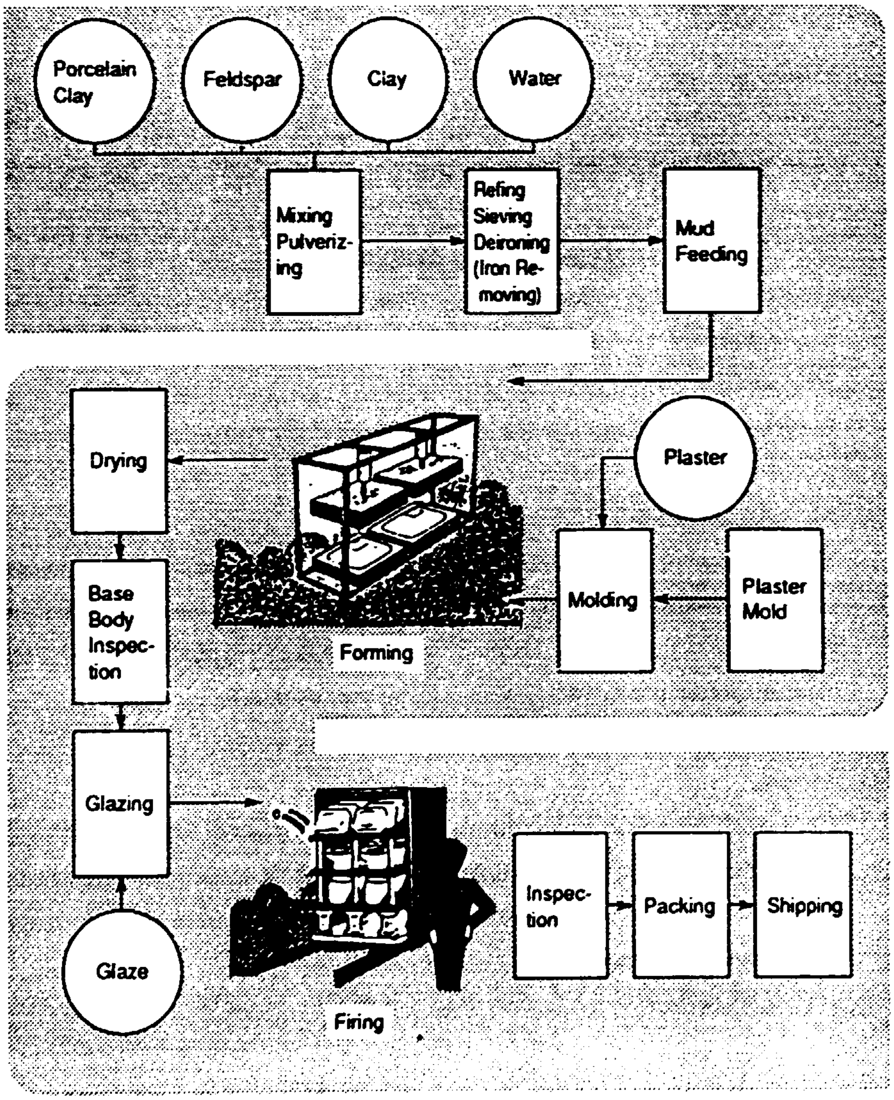


Figure 2 Manufacturing flow of sanitary ware

(1) Raw material

Natural raw materials contain mixtures of various components. The quality of ceramic products will deteriorate if much iron and titanium are contained, so it is necessary to use the materials containing the least of these elements. The components of the natural raw material vary according to the lot to be produced; therefore, it is essential to set up material acceptance standards to inspect chemical components, refractoriness, ignition loss and other related factors.

(2) Crushing

The ore is crushed to get raw materials, and forming and sintering properties vary according to the grain size, as shown below:

	Forming	Sintering
Coarse	Poor	Poor
Fine	Good	Good

It can be seen from the above that the material should be crushed to finer particles.

(3) Blending and kneading

Technical know-how is the most important in this process second to the firing process, and the final product depends on this blending process. The yield, quality and workability are also affected by this process. The major points in the kneading process is how to knead the material uniformly with water and how to mix various materials.

(4) Forming

Metal molds and plaster molds patterns are used in most cases of ceramics forming. Since the ceramics will shrink when fired, it is necessary to take it into account when determining the shape of these molds. Thus, special production know-how is required to produce a mold with a complicated shape.

(5) Drying

The drying process is an important process affecting the product yield, and requires a longer time than many of other processes.

Inappropriate drying may cause the products to be cut or broken; this makes it essential to find out appropriate conditions of temperature, humidity and time.

The waste heat of the kiln is generally used as the heat source for drying. If this is insufficient, the hot air generator is also used to make up for the insufficiency.

(6) Firing

Firing for the pottery and refractories is actually sintering which causes the crystals to be combined with one another. Firing is terminated before the material gets molten. In contrast, temperature is raised until the fired product is molten completely; this is called glass. A kiln is used to manufacture the former product, while a furnace is used to produce the latter.

2. Characteristics of energy consumption in ceramic manufacturing

2.1 Energy consumption

Two types of energy are used in the ceramic industry; electric energy and chemical energy.

The electric energy is used in two different ways; mechanical energy when used in the motor and fan of the machine, and thermal energy when used to heat the kilns and furnaces.

The chemical energy of petroleum fuel is all converted into thermal energy through combustion reaction. Energy used in the ceramic industry is predominantly occupied by petroleum energy. Table 2 illustrates the percentage of the energy cost in the production cost in Japan. As shown, the percentage of the ceramic industry (including cement, glass and pottery) is 8.9 percent, the greatest figure second to iron and steel. The percentage of the energy cost in the total ceramics production cost is between 5 and 20 percent, although it varies according to the product type and fuel price. Reduction of energy cost will contribute to cutting down of the production cost, and increasing of the profit.

Table 2 Energy cost by industry

Basic chemicals	14.2%
Chemical fiber materials	11.3
Pig iron and crude steel	10.3
Ceramic industry	8.9
Pulp and paper	5.3
Rubber product	2.8
Fishery and foodstuff	1.2
Electric machinery	1.0
Precision machinery	0.9
Transportation machinery	0.8
Printing and publication	0.7

Source: Agency of National Resources and Energy

The drying and firing processes in ceramic production use much energy; furthermore, electric machineries (e.g. motor, fan) use electric energy. Of these processes, the firing process is the greatest energy consumer.

Firing is an essential process in the ceramic production process, and heat (combusted exhaust gas, heat when cooling, namely, waste heat) produced in this process is used as a heat source to dry the formed product or as the secondary air for combustion, thus leading to energy conservation.

2.2 Drying process

The drying process in the ceramic industry is the greatest energy consumer second to the firing process. Drying means loss of moisture from the surface of the substance by evaporation, and the drying speed depends on the temperature and humidity. When the substance is dried and moisture is lost, particles are put close to each other, resulting in shrinkage.

Fig. 3 shows the relationship between the drying time and speed. The constant rate drying period is the period when balance is kept between moisture shifting from inside the substance to the surface and moisture evaporation from the surface. The first falling drying rate period is the period when moisture shifts from inside the substance to the surface with reduced moisture evaporating from the surface. The second falling drying rate period is the period when evaporation takes place inside and vapor diffuses to the surface, without moisture shifting from inside the substance. Cracks due to drying is caused during the period when the green body shrinks that is, when the temperature gradient is steep under drying conditions between the constant rate drying period and first falling drying rate period, or when the temperature is excessively low. It is essential to have a correct understanding on these conditions before starting the drying process.

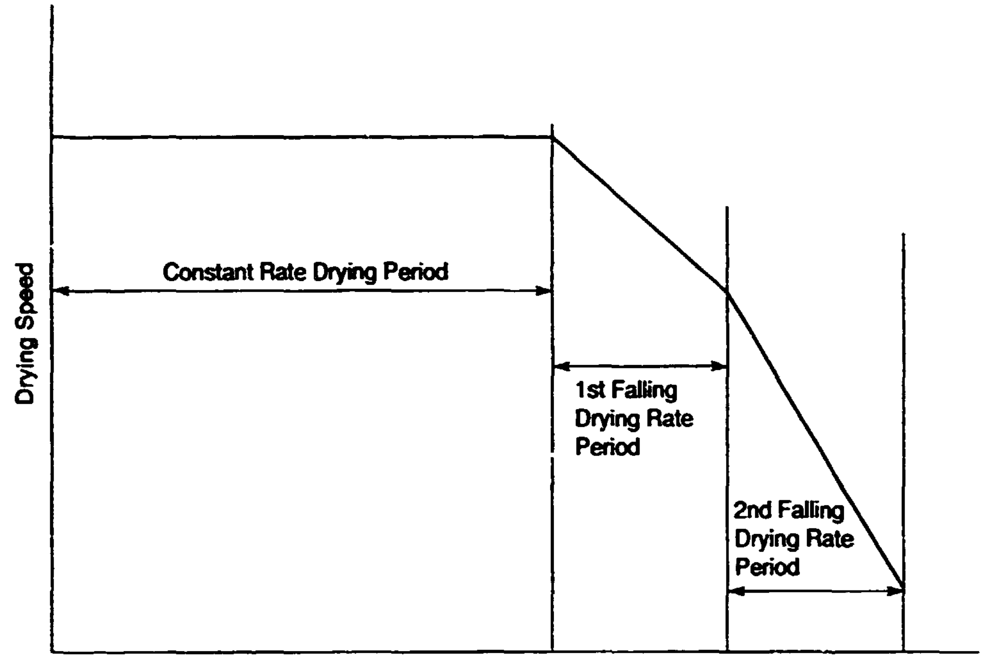


Figure 3 Drying time and speed

2.3 Firing process

The firing process uses a kiln featuring great energy consumption, and natural raw materials are used to produce ceramics. It is essential to have a correct understanding on the following thermal changes (drying, dehydration, decomposition, combination, inversion, vitrification) before working out the firing curve. Fig. 4 shows the heat curve of the porcelain.

(1) Room temperature to 900°C

The green body is dried in the first phase. Normally drying is completed before firing, but it may contain 1 to 2 percent moisture before entering the kiln. This moisture is evaporated before the temperature reaches 200°C. Then, when the temperature is between 300 and 500°C, organic substances contained in the material are carbonized or combusted. The strength of the material is reduced in this period. The water of crystallization of the clay mineral contained in the material is subjected to hydration and decomposition at 500 to 700°C. Since this reaction is an endothermic reaction, heat is absorbed into the gray body, and temperature does not rise. This requires supply of necessary heat in sufficient amount.

The organic substance carbonized at 300 to 500°C is subjected to oxidation from about 800°C, and so-called soot removal is carried out. To remove soot completely during this period, it is necessary to take time to supply sufficient amount of air.

Firing starts partly at the end of the oxidation period, the strength is increased slightly over that of the gray body. If left cooled, the biscuit ware (unglazed earthen ware) will be produced. This is provided with glazing and glost firing. In the case of pottery, there is no dehydration of carbonized clay mineral of the organic substance or oxidation of carbon up to 900°C; therefore, it is not necessary to pay particular attention to the heat curve.

(2) From 900°C to the maximum temperature

Active sintering takes place during this period, and the gray body goes on shrinking considerably. Therefore, temperature must be raised uniformly while sufficient attention is paid to avoid uneven shrinkage and deformation. At this stage of temperature, reduction and sintering may be performed depending on the type of the firing goods. The temperature of the sintered pottery and refractories is raised to the specified value, then heating is terminated. When the gray body is large, temperature differences occur. To prevent this, the product must be kept for some time at the maximum temperature zone.

(3) Cooling

When cooling has started after the maximum temperature is exceeded, the gray body is vitrified to the maximum density, and the glaze is molten to be vitreous. The key point in the cooling process is to cool glass inversion point of the cristobalite at about 573°C and about 250°C gradually when quartz (SiO_2) is included in the gray body. At other temperature ranges it is not affected by the cooling speed, so the speed should be increased maximally to reduce the firing period.

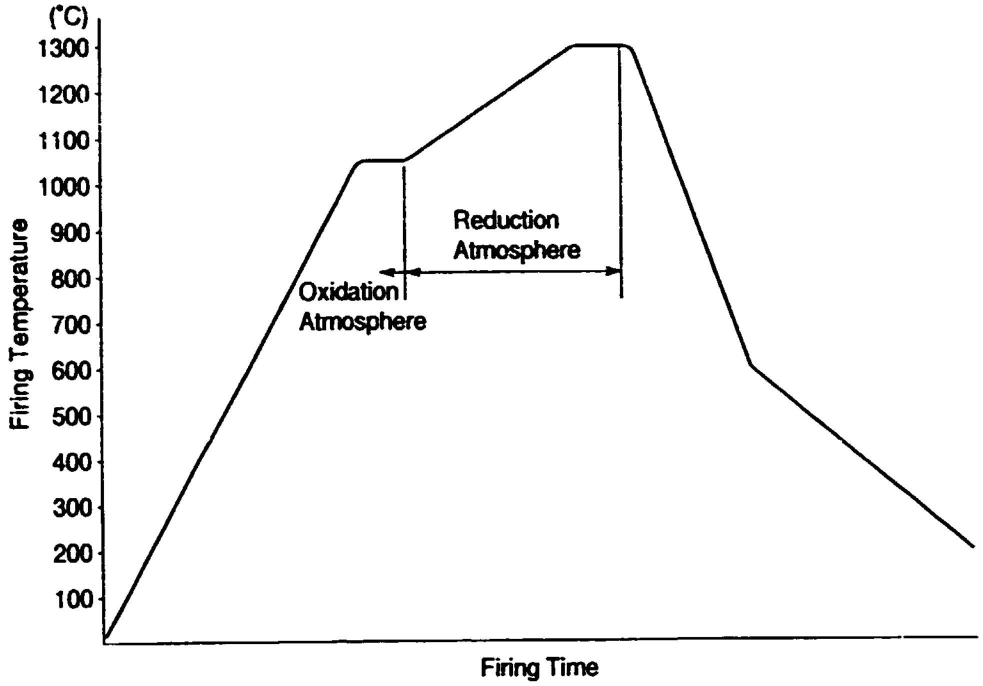


Figure 4 Porcelain heat curve

3. Promotion of energy conservation technique

Energy conservation in industrial sectors starts from the software including operation control and process control, then extends into the field of hardware including equipment improvement and process improvement. Generally, energy conservation efforts can be classified into the following three steps:

Step 1 – Good housekeeping

Energy conservation efforts are made without much equipment investment, including elimination of the minor waste, review of the operation standards in the production line, more effective management, improvement of employees' cost consciousness, group activities, and improvement of operation technique.

For example, such efforts include management to prevent unnecessary lighting of the electric lamps and idle operation of the motors, repair of steam leakage, as well as reinforcement of heat insulations.

Step 2 – Equipment improvement

This is the phase of improving the energy efficiency of the equipment by minor modification of the existing production line to provide a waste heat recovery equipment and a gas pressure recovery equipment or by introduction of efficient energy conservation equipment, including replacement by advanced equipment. For example, energy conservation efforts in this step include an effective use of the waste heat recovery in combustion furnaces and introduction of the furnace top gas pressure recovery generator in the iron and steel works and waste heat recovery generator in cement plant.

Step 3 – Process improvement

This is intended to reduce energy consumption by substantial modification of the production process itself by technological development. Needless to say, this is accompanied by a large equipment investment. However, this is linked to modernization of the process aimed at energy conservation, high quality, higher added value, improved product yield and man power saving.

The following shows the classification of energy conservation techniques in the ceramic industry:

	Drying process	Firing process
1st step	1) Combustion control (combustion temperature)	1) Exhaust gas temperature control 2) kiln seal 3) Cooling air 4) Air ratio 5) Firing management (heat curve, temperature distribution in the kiln, kiln pressure, atmosphere) 6) Loading pattern on the kiln car 7) Clearance between the kiln wall and kiln car 8) Sand seal 9) Kiln car pushing speed
2nd step	2) Heat insulation	1) Refractories on the kiln car (to be light in weight) 2) Refractories in the periodic kiln (to be light in weight) 3) Form of the tunnel kiln 4) Recovery of the exhaust gas 5) Kiln car pushing speed
3rd step		1) Conversion from the tunnel kiln to the roller hearth kiln

3.1 Energy conservation technique in drying process

Electric and gas energy are used for material adjustment and forming in the ceramic production process. The greatest amounts of energy are consumed to dry the formed product and by the kiln (tunnel kiln and shuttle kiln) in the firing process.

Heat during the cooling in the above kiln is generally used as heat source for the formed products in the ceramic production process. However, this heat alone is not sufficient, and the heat regenerator (boiler, hot air generator) is used to make up for this insufficiency.

Therefore, the structure of the drier is so designed that the outer wall is provided with the heat insulation board and wool in order to prevent heat dissipation.

To improve the drying efficiency, the jet type drier is also used in recent years, where hot air directly hits the formed product. What should be borne in mind in this case, however, is that the product may be broken or the plaster mould may be cracked if air with excessive temperature or humidity is used; this is because hot air hits the product at a very high speed. Efforts must be made to find out the appropriate temperature and humidity.

3.2 Energy conservation technique in firing process

3.2.1 Heat balance

The kiln including the tunnel kiln and shuttle kiln consumes the greatest amount of energy in the production process. The following describes the energy conservation for the tunnel kiln and shuttle kiln:

The first step in promoting energy conservation activities is a correct understanding of the current situation. Namely, correct information on how, where and how much energy is used and wasted will make it possible to determine the target for reducing the energy loss and to initiate the improvements. This is known as "heat balance". The heat balance defines the quantitative relationship between the heat supplied to the thermal equipment (heat input) and the consumed heat (heat output). In all cases, the total heat input is perfectly equal to the total heat output. The degree of economic use of heat in a thermal equipment depends on distribution of various types of heat constituting the heat output with respect to heat input.

(1) Heat input

- Heat retained by fuel

  Combustion heat = calorific value of fuel × fuel consumption
- Heat carried in by the heated object

  Volume of heated object × its specific heat × temperature difference

(2) Heat output

- Heat carried away by the heated object

  Volume of heated object × its specific heat × temperature difference
- Heat carried away by waste heat

  Volume of waste heat × its specific heat × temperature difference
- Heat carried away by combusted exhaust gas

  Volume of exhaust gas × its specific heat × temperature difference
- Heat loss by radiation and conduction

  Difference between total heat input and total heat output

(3) Thermal efficiency

The thermal efficiency is expressed by "effective heat" divided by "heat input". The effective heat is defined as the heat required to fire the heated object; namely, it is the volume of heated object by its specific heat by maximum temperature.

Based on the calculation method discussed above, the heat balance of the tunnel kiln (biscuit kiln, glost kiln) and shuttle kiln for the tableware is shown in Table 3 and Fig. 5.

Table 3 Heat balance

		Biscuit kiln		Glost kiln		Shuttle kiln (Glost firing)
		Calorific value (kcal)	%	Calorific Value (kcal)	%	
Input	Heat from combustion of fuel	1685.4×10^3	98.5	6492.6×10^3	99.7	
	Heat from prefiring goods, sagger and kiln furniture	11.2	0.7	6.2	0.2	
	Heat from kiln car	13.9	0.8	3.2	0.1	
	Total	1710.5	100.0	6502	100.0	
Output	Heat loss from firing goods, sagger and kiln furniture	118.0×10^3	6.9	161.3×10^3	2.5	
	Heat loss from kiln car	171.3	10.0	206.1	3.2	
	Heat loss from waste heat	119.0	7.0	2576.4	39.6	
	Heat loss from combustion gas	358.4	21.0	1497.1	23.0	
	Heat loss from radiation, conduction	943.8	55.1	2061.1	31.7	
	Total	1710.5	100.0	6502	100.0	
Thermal efficiency of firing goods		22.3%		7.3%		4.6%
Thermal efficiency of firing goods, sagger and kiln furniture		66.1%		32.9%		18.7%

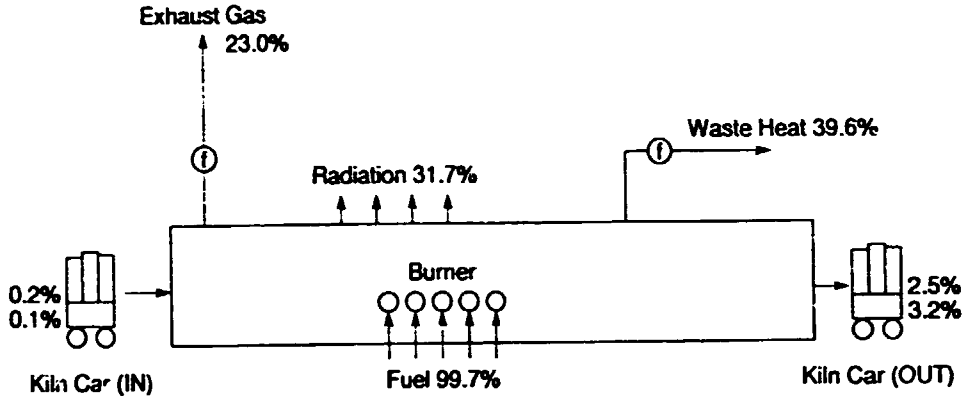


Figure 5 Heat flow of glost kiln

The heat balance clearly shows how heat is used. The thermal efficiency of the fired products alone is very close to 7.3 percent in glost firing. This means that, even when 100 liters of oil are combusted, only 7.3 liters contribute to firing, and the remaining 92.7 liters of oil are wasted, evidencing that this is an extremely ineffective thermal equipment. Then where is it wasted?

As will be clear from the description of the heat output, heat losses by combusted exhaust gas, radiation, conduction, waste heat and kiln car are great.

(1) Heat loss by combusted exhaust gas

Heat loss by exhaust gas can be calculated in the following equation:

$$Q = V \times Cp \times \Delta t$$

where V : Exhaust gas (Nm^3/h)

Cp: Specific heat of exhaust gas ($kcal/Nm^3$ °C)

Δt : Difference between exhaust gas temperature and outer air temperature (°C)

Of these factors, Δt, exhaust gas temperature, should be kept as low as possible, but it should be noted that problems may lie with the dew point. When the fuel has much sulfur content, the dew point is from 120 to 160°C, and the exhaust gas temperature cannot be set below this point. The specific heat of the exhaust gas depends on the temperature, but not very much. Therefore, heat loss by exhaust gas can be considered to be proportional to the volume of exhaust gas.

Normally, many of the tunnel kilns have a smaller internal pressure than the atmospheric pressure in the prefiring zone; this results in entry of the outer air into the kiln. The incoming air not only increases the volume of the exhaust gas, but also reduces the temperature near the position where it has entered. This will cause temperature difference to occur between the upper and lower parts. Therefore, small clearances must be sealed with fibers or similar materials.

(2) Heat loss by radiation and conduction

This heat loss is the loss of heat radiated from the kiln wall, and is related to the surface area of the kiln. This suggests that kiln shape is very crucial.

(3) Heat loss by waste heat

Normally heat is taken from the cooling zone and is used to dry the products. This is considered to be an effective use of heat. However, the heat cannot be obtained without any fuel; some amount of fuel is required. From the viewpoint of the kiln alone, use of much of this waste heat for drying will reduce thermal efficiency of the kiln.

(4) Heat loss by kiln car

This heat corresponds to the heat carried away by the kiln car when it comes out of the kiln. It can be calculated in the following equation:

$$Q = W \times Cp \times \Delta t$$

where W : Weight of the car (kg/car)

Cp: Specific heat of the car refractory (kcal/kg°C)

Δt : Difference between the car temperature at the kiln outlet and outer air temperature (°C)

Cp is a constant to be determined by the material of the refractory to be used. Use of the heat insulation bricks or ceramic fibers will reduce the weight, so the result will be "killing two birds with one stone".

The thermal efficiency of the periodic kiln is 4.6 poorer than that of the tunnel kiln; this is because the temperature is raised or lowered every time, in other words, the kiln is heated and cooled. This is because the heat to raise kiln temperature is greater than the heat released from the kiln wall surface.

The heat reserve Q (kcal) of the kiln is determined by the kiln weight W (kg), the average temperature rise Δt (°C) of the kiln wall within the heating time, and the specific heat of the kiln material Cw (kcal/kg °C).

$$Q = W \times Cw \times \Delta t$$

Thus, in order to make Cw smaller, the periodic kilns in recent years use insulating bricks and ceramic fibers rather than refractory bricks, as is the case with the above mentioned car structure. In this way, reduction in the weight of the kiln material will also mean a reduced Cw-value. This will reduce Q, resulting in a reduced amount of fuel consumption.

Table 4 shows an example of the heat balance recording format for the tunnel kiln for firing the pottery and refractories.

Table 4 Heat balance recording format

(1) Outline of kilns

Factory name		Location	
Person in charge			
Kiln number			
Type and form			
Dimensions (length, width, height) m			
Effective area m^2			
Surface area m^2			
Number of cars in kiln			
Total floor area of car m^2			
Type, capacity and number of burners			
Ventilation	System		
	Fan	Type	
		Volume and pressure Pa{m^3_N · mmAq}	
	Chimney	Dimensions (diameter, height) m	
		Name and number of the equipment for joint use	
Type, form and capacity of the equipment using waste heat			
History			
Remarks			

Source: JIS R0301 Heat balancing of pottery and refractory firing tunnel kiln

(2) Measurement items

Measurement period (time and date)				
Name of measuring person(s)				
Climate	Atmospheric pressure Pa (mmHg)	Outside air temperature °C	Humidity %	Inside air temperature °C
Combustion equipment and ventilator with their conditions				
Firing product				
Kiln load rate %				
Firing time and cooling time h				
Atmosphere within firing zone %		CO_2	O_2	CO

Fuel	Type				
	Properties	Moisture			
		Specific gravity			
		Viscosity			
	Composition	Liquid fuel c, h, s, n, o %			
		Fuel gas O_2, H_2, N_2, CO, CO_2, CH_4, C_2H_6, C_3H_8, C_4H_{10} %			
	Calorific value	High heat value kJ/kg (kcal/kg) or kJ/m^3_N (kcal/m^3_N)			
		Low heat value kJ/kg (kcal/kg) or kJ/m^3_N (kcal/m^3_N)			
	Operating temperature °C				
	Used quantity	Total kg or m^3_N	Total	Firing zone	Preheating zone
		Per product kg or m^3_N			
Air for combustion	Volume	Primary air m^3_N			
		Secondary air m^3_N			
		Per kg or m^3 of fuel m^3_N			
	Temperature	Primary air °C			
		Secondary air °C			
	Pressure	Blower outlet Pa (mmAq)			
		Preheater inlet Pa (mmAq)			
		Preheater outlet Pa (mmAq)			
	Air ratio	Combustion chamber outlet			
		Kiln outlet			
Air for cooling	Volume m^3_N				
	Temperature	Inlet to kiln °C			
		Outlet from kiln °C			
	Pressure	Inlet to kiln Pa (mmAq)			
		Outlet from kiln Pa (mmAq)			

Cooling water	Volume m^3_N or kg		
	Temperature	Inlet °C	
		Outlet °C	
Un-fired product	Type (composition and specific heat)		
	Mass t		
	Moisture	Water adhered %	
		Water of crystallization %	
	Combustible component	% | Calorific value | kJ/kg (kcal/kg)	
		% | Calorific value | kJ/kg (kcal/kg)	
	Temperature at kiln inlet °C		
Fired product	Mass t		
	Maximum firing temperature °C		
	Temperature at kiln outlet °C		
	Firing ignition loss %		
Sagger and kiln furniture	Type (including specific heat for each type)		
	Mass	Sagger t	
		Kiln furniture t	
	Temperature	at kiln inlet °C	
		at kiln outlet °C	
Kiln car	Number		
	Mass per unit	Refractory t	
		Iron part t	
	Temperature at kiln inlet/outlet	Refractory °C	
		Iron part °C	
	Specific heat for each type kJ/kg °C (kcal/kg °C)		
Combusted exhaust gas	Volume	Overall volume m^3_N	
		Per 1kg or $1m^3_N$ of fuel, m^3_N	
	Temperature	Firing zone °C	
		Preheating zone °C	
		Main flue °C	
	Pressure	Firing zone Pa (mmAq)	
		Preheating zone Pa (mmAq)	
		Main flue Pa (mmAq)	
	Composition in main flue (CO_2, O_2, CO) %		
Circulating combustion gas	Volume m^3		
	Temperature at outlet and blowing inlet °C		
Surface temperatures on kiln	Inlet (top, side, door) °C		
	Preheating zone (top, side) °C		
	Firing zone (top, side) °C		
	Cooling zone (top, side) °C		
	Outlet (top, side, door) °C		
	Duct leading from kiln and fans °C		
Remarks			

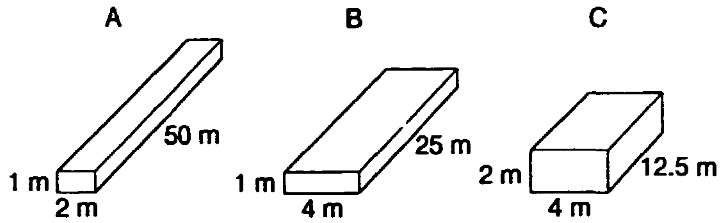
(3) Heat balance

Item			Thermal input 10³ kJ (10³ kcal)	Thermal input %	Thermal output 10³ kJ (10³ kcal)	Thermal output %
Thermal input Q_1	(1) Heat of combustion of fuel	Q_a				
	(2) Sensible heat of fuel	Q_b				
	(3) Heat carried in by prefiring goods, sagger and kiln furniture	Q_c				
	(a) Heat carried in by prefiring goods	Q_{c1}				
	(b) Heat carried in by sagger and kiln furniture	Q_{c2}				
	(4) Heat carried in by car	Q_d				
	(a) Heat carried in by car (refractory)	Q_{d1}				
	(b) Heat carried in by car (iron)	Q_{d2}				
	(5) Heat carried in by combustible component included in the prefiring goods	Q_e				
Thermal output Q_2	(1) Heat carried away by prefiring goods, sagger and kiln furniture	Q_f				
	(a) Heat carried away by prefiring goods	Q_{f1}				
	(b) Heat carried away by sagger and kiln furniture	Q_{f2}				
	(2) Heat carried away by car	Q_g				
	(a) Heat carried away by car (refractory)	Q_{g1}				
	(b) Heat carried away by car (iron)	Q_{g2}				
	(3) Heat carried away by combusted exhaust gas	Q_h				
	(4) Heat carried away by cooling air	Q_i				
	(a) Heat carried away by dried exhaust gas	Q_{i1}				
	(b) Sensible heat of vapor in the combusted exhaust gas	Q_{i2}				
	(5) Heat loss by incomplete combustion	Q_j				
	(6) Heat carried away by steam evaporated from the prefiring goods moisture	Q_k				
	(7) Heat carried away by cooling water	Q_l				
	(8) Heat loss by radiation and conduction	Q_m				
	Total					
Circulating heat Q_3	(1) Heat recovered by air for combustion	Q_n				
	(2) Heat retained by circulation combustion gas	Q_o				
Effective heat Q_4	(1) Effective heat per ton of fired products in the presence of fired products alone	Q_1				
	(a) Heat required to evaporate moisture of the prefiring goods	Q_p				
	(b) Heat required to evaporate water of crystallization from the prefiring goods	Q_q				
	(c) Heat required to decompose the clay	Q_r				
	(d) Heat required to fire the prefiring goods	Q_s				
	(2) Effective heat per ton of the fired products when the sagger and kiln furniture are included	Q_{11}				
	(a) Heat required to heat the sagger and kiln furniture	Q_t				
Thermal efficiency η	(1) Thermal efficiency of the fired product	η_1				%
	(2) Thermal efficiency when the sagger and kiln furniture are included	η_2				%

3.2.2 Structure of kiln

The basic requirement to save fuel is high speed firing — to fire the material in the minimum time. The requirement for rapid firing in the tunnel kiln is that the temperature be uniform at all positions — upper, lower, right or left position — in the sectional area at a right angle to the pass of the kiln car.

Fig. 6 shows the differences in sizes according to the type of the tunnel kiln.



	A	B	C
Capacity (m^3)	100	100	100
Surface Area (m^2)	200	150	100
Kiln Car (Car)	100	100	50
Floor Area (m^2)	100	100	50

Figure 6 Size of tunnel kiln

As is clear from the above, assuming that the material is to be heated at the same firing curve whether in the tunnel kiln or shuttle kiln: Then if the internal capacity of the kiln is constant, the surface area of kiln C which is close to a cube, is half as much as that of kiln A, allowing the required amount of the kiln refractories, the number of the firing cars, floor space and heat carried away by the cars also to be reduced to a half.

Reduction of the surface area to a half will reduce the heat radiated from the kiln surface again to a half, resulting in substantial fuel saving.

The pushing speed of kiln car of kiln C is one fourth that of kiln A. As can be seen, the physical travel distance of the kiln car is small even if time required for heating and cooling is the same.

Rapid firing ensures energy conservation. To cut the firing time as well as to reduce the weight of the kiln refractories, the modern shuttle kiln uses a high speed burner or excess air burner which agitates within the kiln to ensure uniform temperature distribution. Fig. 7 shows the layout of the shuttle kiln burner.

As discussed previously, in the kiln car fiber board is used to minimize the weight, thereby improving insulation effect and reducing the fuel consumption. Fig. 8 shows the insulation materials of the kiln car.

The following describes the use of waste heat in the tunnel kiln. As shown in Fig. 9, heat of exhaust gas is used for preheating of combustion air with a heat exchanger. Waste heat from cooling zone is used for drying the products and the heated cooling air from cooling zone is used as the secondary combustion air.

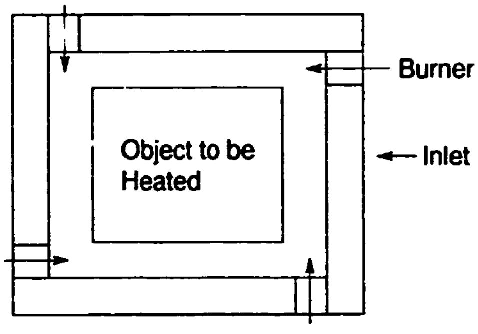


Figure 7 Shuttle kiln

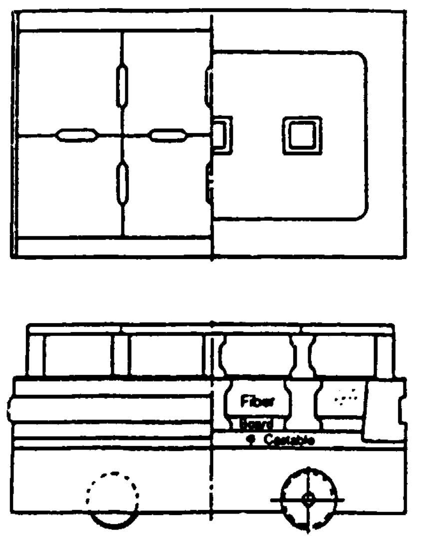


Figure 8 Kiln car

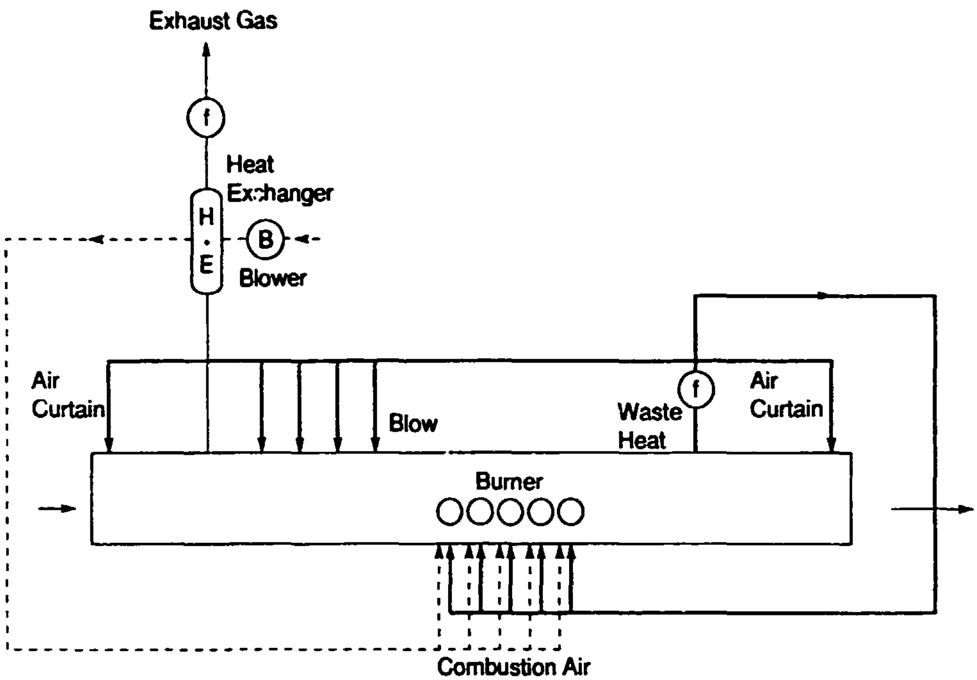


Figure 9 Tunnel kiln

3.2.3 Roller hearth kiln

As discussed previously, rapid firing requires uniform temperature. This, in turn, requires the reduced height inside the kiln; the ratio of the width to height within the kiln is normally 1 to 0.8. If the ratio is reduced to 1 to 0.2, it will further reduce the temperature differences between the top and bottom.

The roller hearth kiln represents the kiln with reduced height. Figs. 10 and 11 show the roller hearth kiln. This kiln is designed as a continuous kiln where the roller conveyer is installed from the kiln inlet to the outlet. Each roller (made of ceramic) rotates to carry the product to be fired from the inlet to the outlet.

Unlike the tunnel kiln, this structure eliminates the use of the kiln car, and the material is placed to be fired on the matting (refractory) known as "setter" whenever required.

As described, the temperature difference of the roller hearth kiln is within plus-minus 3°C at the place where temperature is the maximum, and this feature ensures stable quality of the fired products and improved yield.

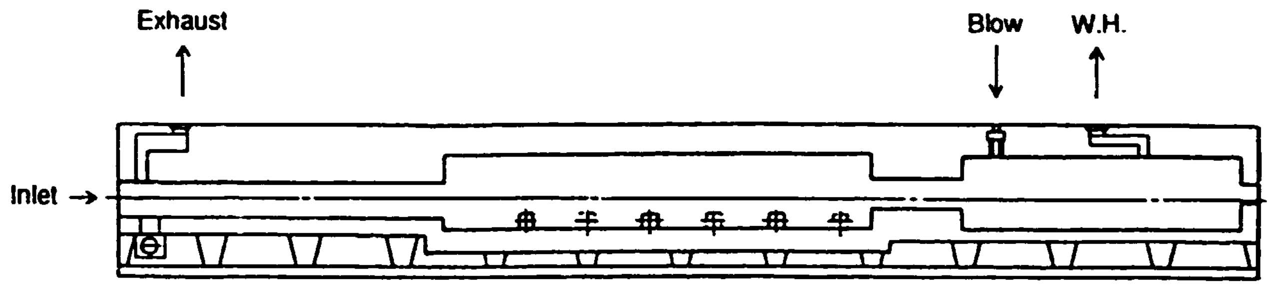
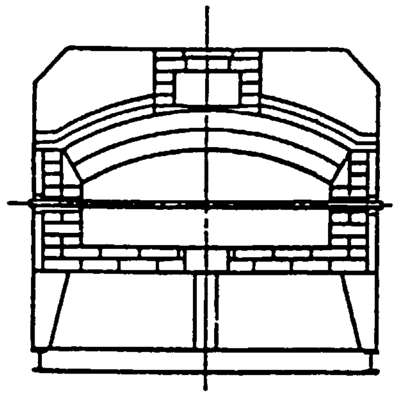
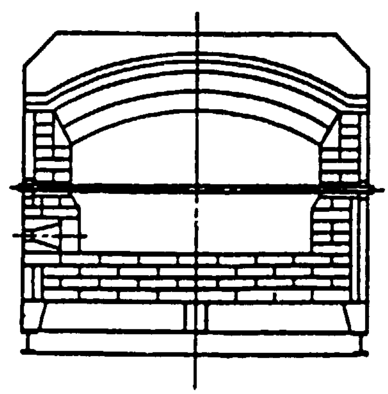


Figure 10 Roller hearth kiln



Pre-firing Zone



Firing Zone

Figure 11 Roller hearth kiln

Small differences of temperatures allow faster firing of the product than by the conventional tunnel kiln, requiring less fuel and contributing to energy conservation.

Tables 4 and 5 show the comparison of the firing cycle and fuel unit consumption between the tunnel kiln and roller hearth kiln.

In addition to the above features, the roller hearth kiln permits quick temperature rise, shut-down, cooling and easy change of the temperature and atmosphere; temperature control is automatic, and firing and shut-down can be performed by the one-touch operation.

Table 4 Firing temperature and firing time

		Temperature	Firing cycle	
			Conventional tunnel kiln	Roller hearth kiln
Table ware	Decoration	750 - 850°C	2 - 5 hours	120 minutes
	Biscuit firing	800 - 1000	20 - 30	120
	Glost firing	1250 - 1350	30 - 40	240
	In-glaze	1200 - 1300	30 - 40	120
Tile	Floor	1250 - 1300	20 - 30	80
	Wall	1060 - 1150	20 - 30	30
Sanitary ware		1220 - 1250	20 - 30	420

Table 5 Thermal efficiency

		Conventional tunnel kiln	Roller hearth kiln
Table ware	Decoration	2500 - 4000 kcal/kg	1500 - 2500 kca/kg
	Biscuit firing	2500 - 4000	1500 - 2500
	Glost firing	5000 - 7000	3000 - 4000
	In-glaze	4000 - 5000	2000 - 3000
Tile	Floor	2300 - 3500	1200 - 1400
	Wall	1500 - 2500	500 - 600
Sanitary ware		5000 - 7000	3000 - 4000

3.2.4 Air ratio in kiln

When the fuel is combusted at the outlet of the firing kiln, it would not be an effective combustion if smoke is produced from the kiln and the smoke of offensive smell is led through the factory, or combustion is intermittent. The air ratio in the combustion chamber (excess air ratio) may be used to check if the burner combustion is effective or not.

Generally, complete combustion of the fuel requires excess air.

The relationship between the volume of actual combustion air A and volume of theoretical combustion air A_0 can be expressed in the following equation:

$$A = mA_0$$

The ratio "m" of the volume of actual air to the volume of theoretical air is called air ratio or excess air ratio.

When this ratio "m" is over 1, complete combustion takes place to create oxidizing atmosphere; in contrast when this ratio "m" is below 1, incomplete combustion takes place to create reducing atmosphere.

Generally, for pottery firing in oxidizing atmosphere, "m" should preferably be within the range from 1.2 to 1.5; below 1.2, the amount of combustion gas becomes insufficient resulting in larger difference in temperature in the kiln, while over 1.5, the amount of combustion gas becomes excessive resulting in smaller difference in temperature in the kiln, but requires fuel more than necessary.

On the other hand, in reducing atmosphere there is no need to increase the value more than necessary (m = below 0.8). To check the air ratio in the combustion chamber in practice, it is possible to calculate it by gas analysis for the combustion chamber.

Liquid fuel

$$m = \frac{21\,(N_2)}{21(N_2) - 79\{(O_2) - 0.5(CO)\}}$$

Gas fuel

$$m = \frac{(O_2) - 0.5(CO)}{5 \cdot C_3H_8 + 6.5\,C_4H_{10} \times \dfrac{(CO_2) + (CO)}{3\,C_3H_8 + 4\,C_4H_{10}}}$$

where symbols in parentheses indicate the composition of the combustion gas (%), and C_3H_8 and C_4H_{10} show the percentage of propane and butane contained in the fuel gas.

Thus, it is important always to analyze the combustion gas to ensure appropriate combustion. In other words, the easiest way of energy conservation for using fuel without investment is to reduce the air ratio. Figures 12 and 13 show the relationship between the air ratio, fuel saving and heat loss. It was pointed out in the discussion of heat balance in 3.2.1 that loss of exhaust gas is great. The volume of exhaust gas depends on the m-value of that gas. Thus, it is important to minimize the percentage of O_2 in the exhaust gas.

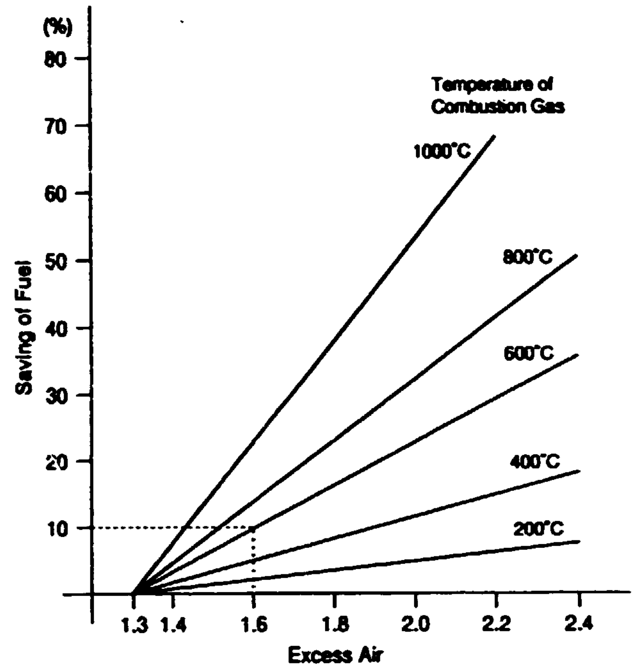


Figure 12 Excess air – saving of fuel

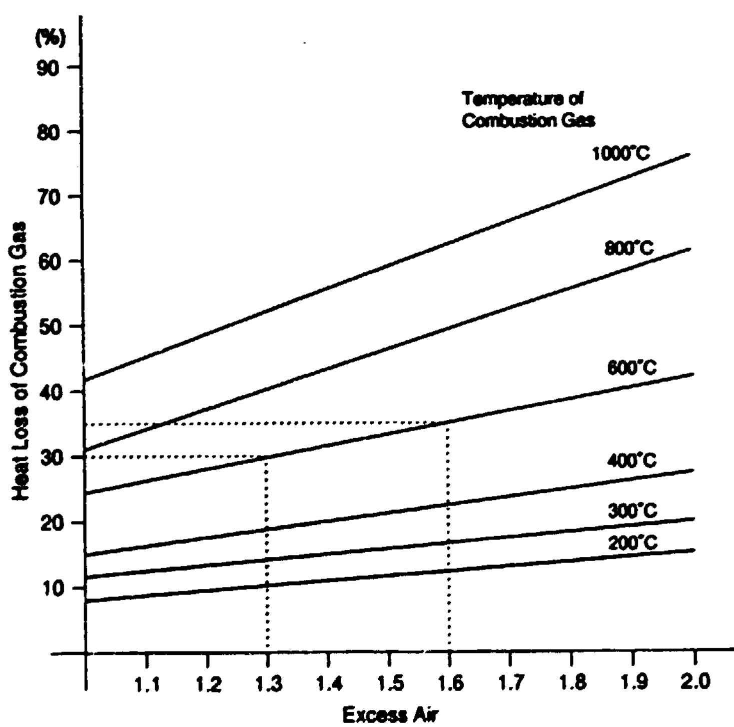


Figure 13 Excess air – heat loss of combustion gas

3.2.5 Pushing speed of kiln car

As discussed in 3.2 and 3.3, uniform temperature is essential to ensure rapid firing. Uniform temperature ensures stable product quality and improved yield.

Although not widely known, the faster the kiln car pushing speed (shorter the firing cycle), the less fuel will be consumed in the tunnel kiln; this will contribute to energy conservation.

The following examples will explain this:

Conditions	Current car speed	30 cars/day
	Fuel consumption	100 ℓ/hour
	Thermal efficiency	30%

The fuel required to fire the products of daily 30 cars under these conditions is given by:

100 ℓ/hour × 0.3 = 30 ℓ/hour

Fuel required to maintain the kiln temperature is:

100 ℓ/hour × 0.7 = 70 ℓ/hour

Let us assume that the thermal efficiency and the fuel required to maintain the kiln temperature remain unchanged, despite possible change of the car speed. If the car speed is increased to 40 cars per day, then the fuel requirement can be expressed in the following equation:

Fuel required to maintain the kiln temperature: 70 ℓ/hour

Fuel required to fire the products:

30 ℓ/hour × 40 cars/day / 30 cars/day = 40 ℓ/hour

Total 70 ℓ + 40 ℓ = 110 ℓ = 110 ℓ/hour

On the other hand,

the fuel consumption per car is given by the following:

30 cars/day: 100 ℓ/hour × 24 hours/day / 30 cars/day = 80 ℓ/car

40 cars/day: 110 ℓ/hour × 24 hours/day / 40 cars/day = 66 ℓ/car

Thus, an increase of the car speed from 30 to 40 cars per day will increase fuel consumption per hour by 10 percent from 100 ℓ/hour to 110 ℓ/hour. In terms of per-car value, the value changes from 80 ℓ/car to 66 ℓ/car, showing that as much as 20 percent energy conservation can be achieved. Thus, less fuel consumption will result in less cost.

3.3 Firing control of kiln

The pottery firing kiln can be classified broadly into two types, the continuous kiln such as tunnel kiln, and the periodic kiln (batch kiln) such as shuttle kiln. The tunnel kiln is suited to mass production, while the periodic kiln is fitted to small quantity production of multiple product types. The kiln should be selected according to the type and volume of the products. The tunnel kiln suited to mass production is less fitted to handle variations of the production volume, whereas the periodic kiln is more fitted to handle such a situation. In this way, each type has its own merits and demerits. Even if the appropriate type of the kiln has been selected, product quality and yield will be poor without adequate daily firing control; it will have an adverse impact on the production and will cause waste of much energy. Thus, firing control is a key point in the firing process.
The following describes the firing control for the tunnel kiln:

The basic concept in the tunnel kiln is that the specified products will be obtained if input and output are kept constant. This should be borne in mind in the firing control; then stable product quality and improved yield will be ensured.

Major points for firing controls are:

(1) Heat curve conforming to the fired product type and production volume
(2) Uniform kiln internal temperature distribution
(3) Maintenance of adequate kiln pressure
(4) Maintenance of adequate atmosphere

These requirements must be met. For this purpose, firing conditions should be controlled using such measuring instruments as the thermometer, pressure gauge and gas analyzer.

Fig. 14 shows the temperature, atmosphere and pressure of the tunnel kiln for porcelain glost firing; it exhibits the specific characteristics of high-temperature reducing atmosphere. It is important to ensure complete oxidizing atmosphere in the prefiring zone, with top priority in keeping the reducing atmosphere of the firing zone constant. While the volume of the combustion gas in the firing zone is kept constant, and the flow of the combustion gas going from the firing zone to the prefiring zone is also kept constant at all times, adequate kiln pressure should be ensured so that counterflow against the cooling zone will not occur.

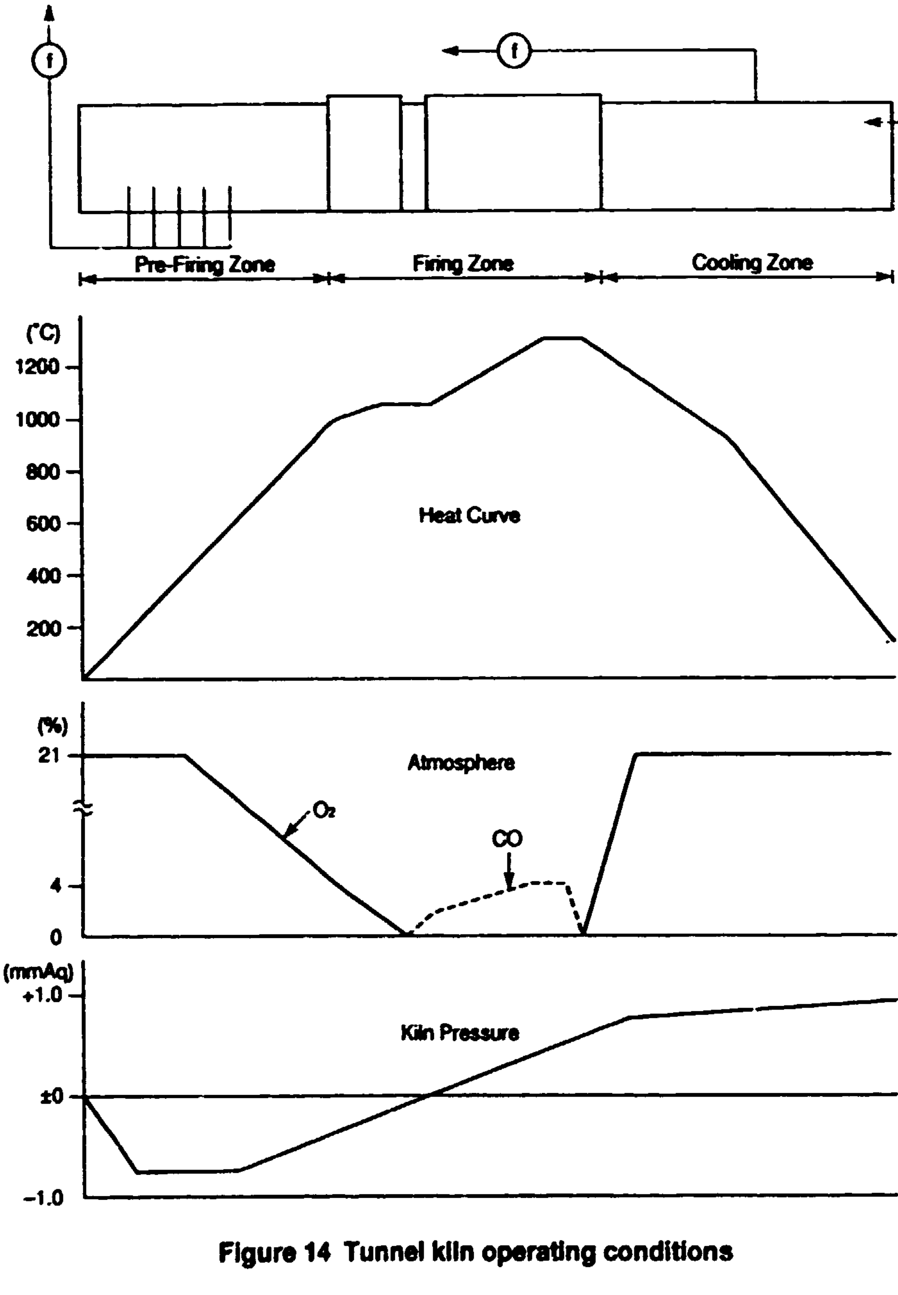


Figure 14 Tunnel kiln operating conditions

To keep the flow of the combustion gas in the firing zone constant, it is necessary to keep kiln pressure before and after the firing zone constant at all times. To keep the volume of this combustion gas and kiln pressure constant, the following steps must be taken:

(1) The pattern of loading the fired products on the kiln car must be uniform.
In practice this is difficult for some types of production. However, it is very important to ensure stable flow of combustion gas. Basically, clearances between saggers should be uniform. The major consideration need not be placed on the weight of the products and saggers, except when there are some considerable changes. It is necessary that the sagger stack height and the area the saggers occupy in the kiln car be the same for all cars.
Fig. 15 shows an example of the loading pattern.

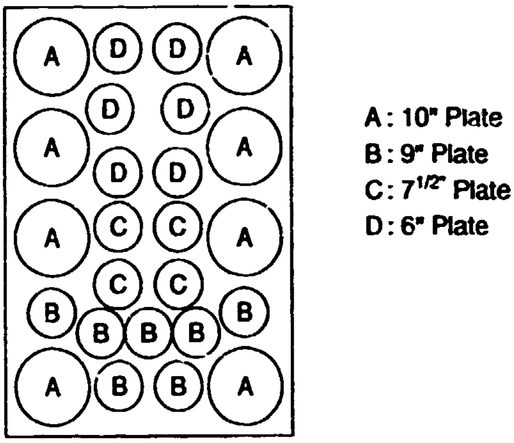


Figure 15 Loading pattern

(2) The fuel (oil, gas) to be supplied must be made constant.

(3) The volume of the primary and secondary air for fuels to be supplied must be made constant.

(4) The kiln pressure after the firing zone must be constant.
To keep the flow of the air going from the cooling zone to the firing zone always constant, a balance should be maintained at some point between the waste heat directly taken out of the cooling zone and the product cooling air to be blown in from the kiln outlet. Then the flow is automatically kept constant.

If the above discussed procedures are taken, the temperature curve and atmosphere will be kept constant, the product quality will be improved and maintained at a stable level.

In addition to the firing control discussed above the following steps should be taken in the daily operation:

(5) Thermometer (thermocouple) maintenance

Normally, the thermocouple inserted in the kiln will deteriorate as it is used, so the current deterioration must be compensated. To measure the deterioration, read the temperature of the currently inserted thermocouple and extract it from the kiln; then insert a new thermocouple. When the temperature has been stable, read the temperature of the thermocouple. This will inform the difference of temperatures between the new thermocouple and the old one, and this difference corresponds to the degree of deterioration. Thus, the target temperature must be reduced by the amount of this deterioration.

E.g.:

Current target temperature	1250°C
Current temperature	1245°C
Temperature of the new thermocouple	1255°C
Deterioration (difference)	10°C
New target temperature	1250°C → 1240°C

In addition to the compensation for the thermometer, it is necessary to calibrate the temperature recorder and indicator, using a special-purpose calibration instrument. The thermocouple undergoes deterioration quickly when it is exposed to the reducing gas such as carbon monoxide. So care should be taken to prevent it from being exposed directly to the gas. Especially when the protective tube is loaded into the kiln or is removed from the kiln, it is likely to break. So sufficient care must be taken to avoid such an accident.

The thermocouple and temperature recorder should be calibrated once in six months at least. Fig. 16 shows the thermocouple.

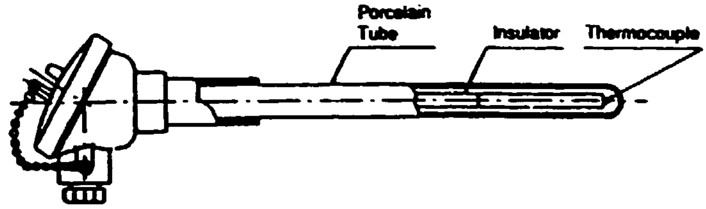


Figure 16 Thermocouple

(6) The space between the kiln wall and kiln car should be made as close as possible.

The combustion gas flowing in the kiln will flow where resistance is the smallest. If there is a big clearance between the kiln wall, kiln car and ceiling, the gas will go there without flowing to the center; this will create temperature differences. To prevent this, the space between the kiln wall and kiln car should be made as close as possible so that gas will flow to the center.

Fig. 17 shows the relationship between the tunnel kiln and kiln car.

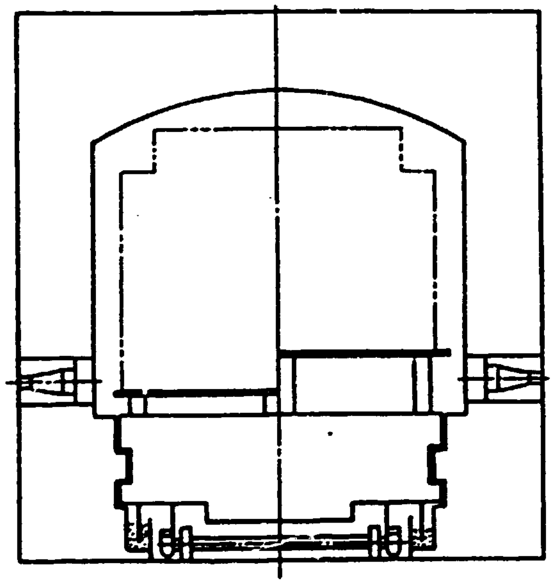


Figure 17 Section of tunnel kiln and kiln car

(7) Fill the kiln with sand for sand sealing.

The sand which seals the kiln interior and the kiln car is provided to prevent air from entering the kiln through the car bottom.

If air enters the kiln due to shortage of this sand, the incoming air reduces the temperature at the bottom of the prefiring zone in the tunnel kiln, resulting in greater temperature differences between the top and bottom.

If the incoming air enters the firing zone fired by reducing atmosphere through the car bottom, the atmosphere will change locally into oxidizing atmosphere, causing the temperature to be raised and the atmosphere to be disturbed. Then defects will occur to the fired product, resulting in poor yield. Thus, the sand seal is a very important part in the kiln structure. It is essential to check the amount of the sand in the daily inspection routine. If the sand is found to be insufficient, replenish it.

Fig. 18 shows the sand seal section.

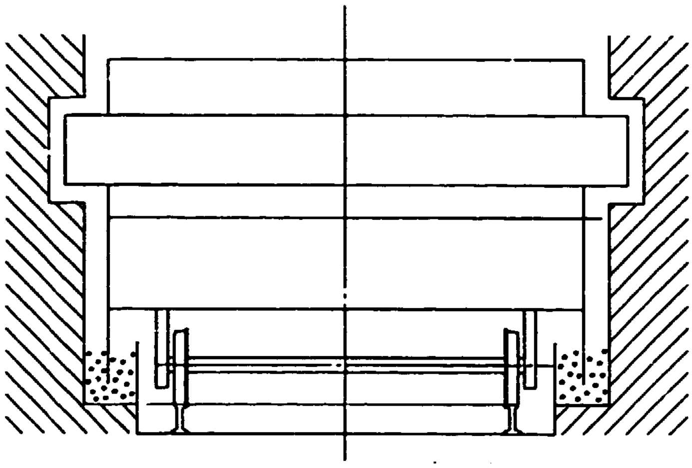


Figure 18 Sand seal of kiln car

(8) Do not allow the kiln car pushing speed to be changed suddenly.

The kiln car pushing speed may have to be changed due to increase or decrease in the amount of production. In this case, do not change the speed very much at one time; it must be slowly changed little by little.

Even if the temperature is raised or lowered, the effect on the product will be delayed. Even though the thermometer indicates a temperature change, there is no change to the product temperature; time will be required before the normal state is resumed.

Normally when the pushing speed is changed, the range of adjustment should be within 5 minutes and a change should be made once a week, even though it varies according to the kiln size. If the speed is changed more frequently, firing of the product may be insufficient or excessive.

To change the kiln car pushing speed, the fuel must be increased or decreased.

For this adjustment, it will be advisable to use the method of calculation as discussed in items 3.2.5 and to use it as a guideline.

(9) Implementation of heat balance

Calculation of fuel consumption to the change of the production volume as described in Item (8) and the heat balance of a kiln should be implemented once a year at least.

Implementation of these firing control items will lead to stable temperature distribution and atmosphere, resulting in higher product quality and improved yield.

HANDY MANUAL

CEMENT INDUSTRY

Output of a Seminar on Energy Conservation in Cement Industry

Sponsored by

United Nations Industrial Development Organization (UNIDO)

and

Ministry of International Trade and Industry (MITI), Japan

Hosted by

Ministry of Energy and Mineral Resources, Bangladesh

Ministry of Power and Energy, Sri Lanka

Organized by

The Energy Conservation Center (ECC), Japan

1994

Bangladesh **Sri Lanka**

PREFACE

The conservation of energy is an essential step we can all take towards overcoming the mounting problems of the worldwide energy crisis and environmental degradation. In particular, developing countries are interested to increase their awareness on the inefficient power generation and energy usage in their countries. However, usually only limited information sources on the rational use of energy are available.

The know-how on modern energy saving and conservation technologies should, therefore, be disseminated to government and industrial managers, as well as to engineers and operators at the plant level in developing countries. It is particularly important that they acquire practical knowledge of the currently available energy conservation technologies and techniques.

In December 1983, UNIDO organized a Regional Meeting on Energy Consumption as well as an Expert Group Meeting on Energy Conservation in small- and medium-scale industries for Asian countries. During these meetings, it was brought out that, for some energy intensive industries, savings up to 10% could be achieved through basic housekeeping activities, such as auditing and energy management.

All these experiences brought UNIDO to prepare a regional programme on the promotion and application of energy saving technologies in selected subsectors, since the rational use of energy calls for a broad application of energy conservation technologies in the various industrial sectors where energy is wasted. One of these energy intensive industrial sectors to be considered to improve efficiency through the introduction of modern energy conservation technologies is the cement industry.

The cement industry consumes much energy. The cement industry is also noted for great percentage of the energy cost in the total production cost.

In the cement industry, appreciable amounts of energy could be saved or conserved by preventing of leakage in the kilns, modifying the equipment to recover heat from the preheater and cooler in the process of cement-making and effective use of industrial waste materials.

Currently, UNIDO is implementing this programme with the financial support of the Japanese Government, in selected Asian developing countries. This programme aims at adapting these innovative energy conservation technologies, developed in Japan, to the conditions of developing countries.

In this programme, we are considering that the transfer of these technologies could be achieved through:

(i) Conducting surveys of energy usage and efficiency at the plant level;

(ii) Preparing handy manuals on energy management and energy conservation/saving technologies, based on the findings of the above survey;

(iii) Presenting and discussing the handy manuals at seminars held for government officials, representatives of industries, plant managers and engineers;

(iv) Disseminating the handy manuals to other developing countries for their proper utilization and application by the industrial sector.

The experience obtained through this programme will be applied to other programmes/projects which involve other industrial sectors as well as other developing countries and regions.

UNIDO has started this programme with the project US/RAS/90/075 - Rational Use of Energy Resources in Steel and Textile Industry in Malaysia and Indonesia and the project US/RAS/92/035 - Rational Use of Energy Saving Technologies in Pulp/Paper and Glass Industry in Philippines and Thailand. These were followed by project US/RAS/93/039 Program for the Use of Energy Saving Technologies in the Ceramic and Cement Industries in Sri Lanka and Bangladesh.

The present Handy Manual on Cement Industry was prepared by UNIDO, with the cooperation of experts from the Energy Conservation Center (ECC) of Japan, on energy saving technologies in the framework of the above-mentioned UNIDO project. It is based on the results of the surveys carried out, the plant observations and the recommendations and suggestions emanating from the Seminars on Energy Conservation in the Cement Industry, held under the same project in May 1994 in Dhaka, Bangladesh and Colombo, Sri Lanka respectively. The handy manual will not only be interesting for government and representatives from industry, but it is, in particular, designed for plant-level engineers and operators in developing countries as a tool to improve energy efficiency in the production process.

Appreciation is expressed for the valuable contribution made by the following institutions to the successful preparation and publication of the manual mentioned above:

Ministry of Energy and Mineral Resources, Bangladesh

Ministry of Power and Energy, Sri Lanka

Ministry of International Trade and Industry (MITI), Japan

The Energy Conservation Center (ECC), Japan

June 1994

CONTENTS

1. Production process of cement

In the times of Egypt and Greece, sintered and ground lime or plaster was used as cement for civil engineering and construction. In the 19th century, portland cement was produced in England. This manual covers energy conservation in portland cement production.

A cement production plant consists of the following three processes.

1. Raw material process
2. Clinker burning process
3. Finish grinding process

The raw material process and the clinker burning process are each classified into the wet process and the dry process.

In the wet process, raw materials other than plaster are crushed to a diameter of approximately 20 mm by a crusher and mixed in an appropriate ratio using an automatic weigher, as shown in Fig. 1. Then, with water added thereto, the mixture is further made finer by a combined tube mill with a diameter of 2 to 3.5 m and a length of 10 to 14 m into slurry with a water content of 35 to 40%. The slurry is put in a storage tank with a capacity of several hundred tons, mixed to be homogenized with the corrective materials, and is sent to a rotary kiln for clinker burning. In the wet process, the slurry can be easily mixed but a large amount of energy is consumed in clinker burning due to water evaporation.

In the dry process, crushed raw materials are dried in a cylindrical rotary drier having a diameter of 2 m and a length of about 20 m for example, mixed by an automatic weigher, ground and placed in storage tanks. The resultant mixture is further mixed to make the ingredients uniform, and sent to a rotary kiln for clinker burning.

These processes are selected with consideration given to properties of raw materials, costs of fuel, conditions of location and others. For the wet process, plant construction cost is rather low and high-quality products are manufactured easily. On the other hand, the dry process consumes less energy and its running cost is lower.

The progress of technology is, however, eliminating the differences in quality between products from the above processes, while needs for energy conservation are getting increasingly strong. In future, the wet process will not be employed positively.

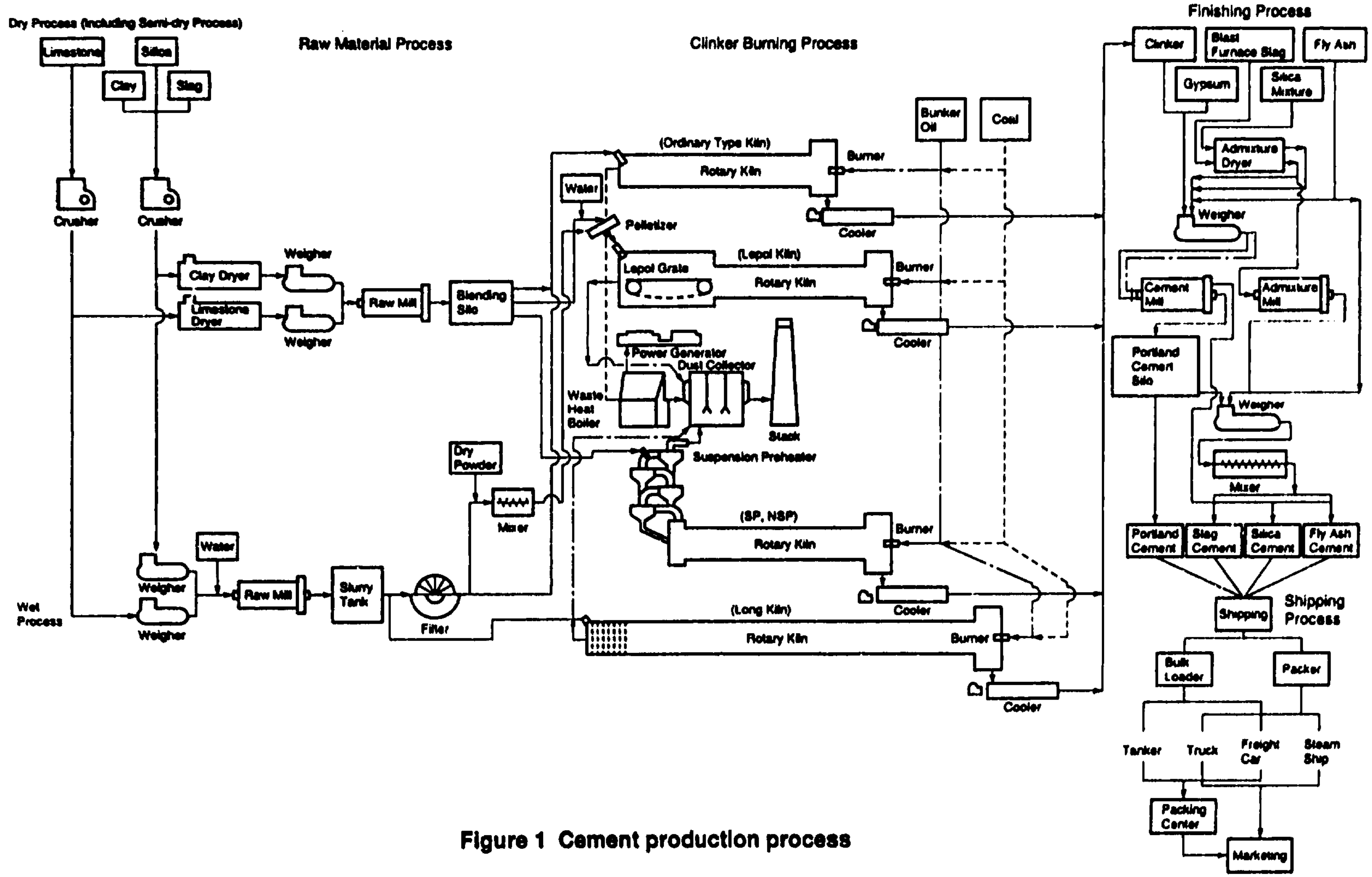


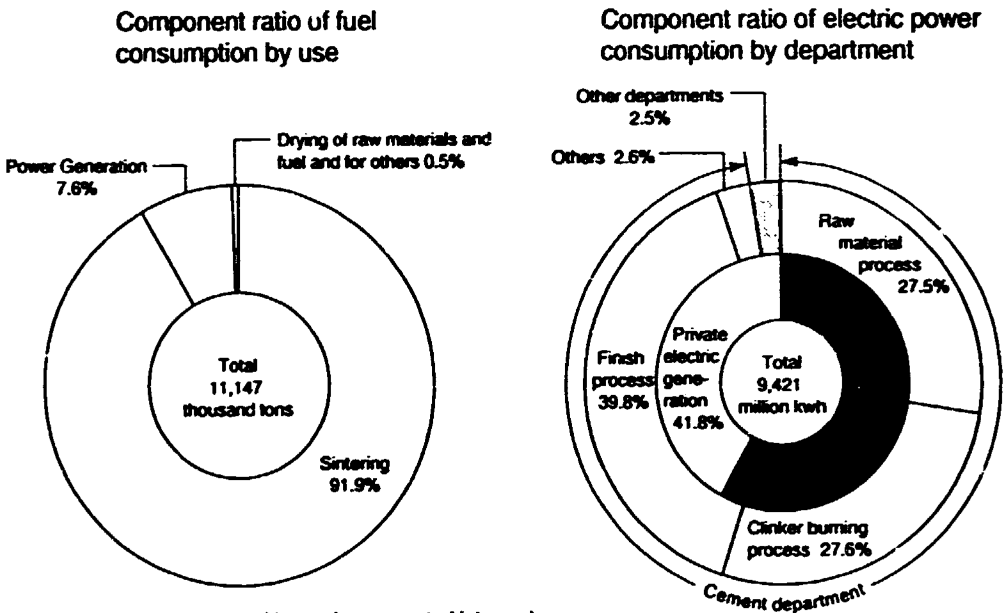
Figure 1 Cement production process

2. Characteristics of energy consumption in cement production

2.1 Energy consumption

The cement industry is said to be an energy-intensive industry together with steel, paper and petrochemical industries. The percentage of energy cost in portland cement production cost is 20 to 30%. If the energy cost is reduced, the manufacturing cost is lowered, resulting in increasing the company's profits.

Fig. 2 shows the component ratio of fuel and electric power consumption by the whole cement industry in Japan.



(Note) Total is expressed in a value converted into coal (calorific value: 6,200 kcal/kg)

Source: Cement in Japan 1993, Japan Cement Association (JCA)

Figure 2 Component ratio of energy consumption in 1992

Ninety percent or more of fuel is consumed for clinker burning. About 40% of electric power is consumed for finish grinding, and a little under 30% each is consumed by the raw material process and the clinker burning process. The finish grinding process mainly consumes electric power for the mill, and the clinker burning process mainly for the fan.

The raw material grinding process consumes a large volume of power for the mill and fan.

The Japanese cement production process is mostly occupied by SP and NSP kilns and coal is used as fuel, so that the ratio of electric power consumption by the clinker burning process is high. In a plant mainly using a wet process kiln, the finish grinding process consumes power in a larger quantity than the aforementioned example. In such a case, energy conservation measures shall be taken by focusing on the clinker burning process for the fuel consumption and on the finish grinding process for the electric power consumption.

2.2 Raw material process

2.2.1 Wet process

Since raw materials can be homogenized and the mixing ratio can be corrected after grinding, this process is relatively simple. A typical example is shown in Fig. 3.

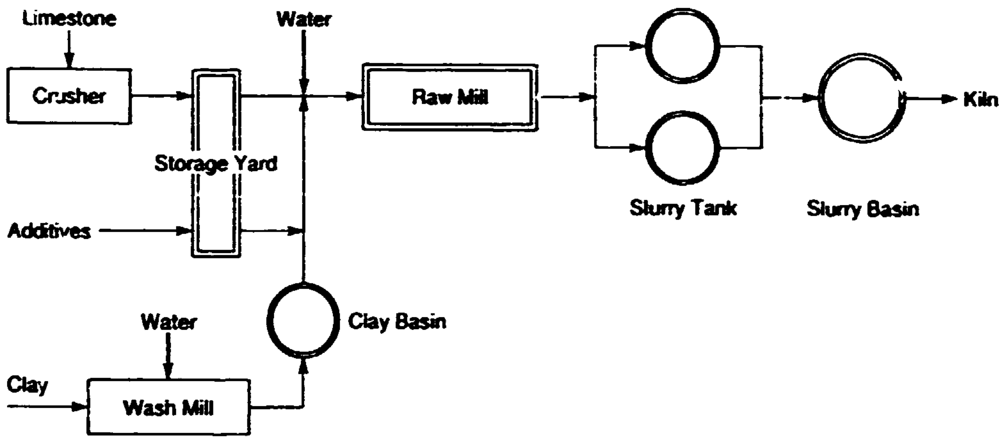


Figure 3 Wet process raw material grinding system

2.2.2 Dry process

Fig. 4 shows three processes a, b and c. Raw materials received by a plant contain a small amount of water. Limestone contains 2 to 5% of water and clay about 5 to 10%. The dry process needs to evaporate water when grinding. In Fig. 4, process a is provided with an independent dryer to evaporate water, and the dryer may be a rapid dryer or impact dryer with a disintegrating or crushing function instead of the rotary dryer as illustrated.

In Fig. 4, process b is a closed circuit grinding process combining an air separator and a ball mill or tube mill, which is provided with drying function. The above mill and separator are available in several types.

In Fig. 4, process c is an example of vertical roller mill.

For drying, exhaust gas from the kiln and preheater is used, but sometimes a hot gas generator is installed for a time of commissioning of the plant and for a time of year when water contained in raw materials increases.

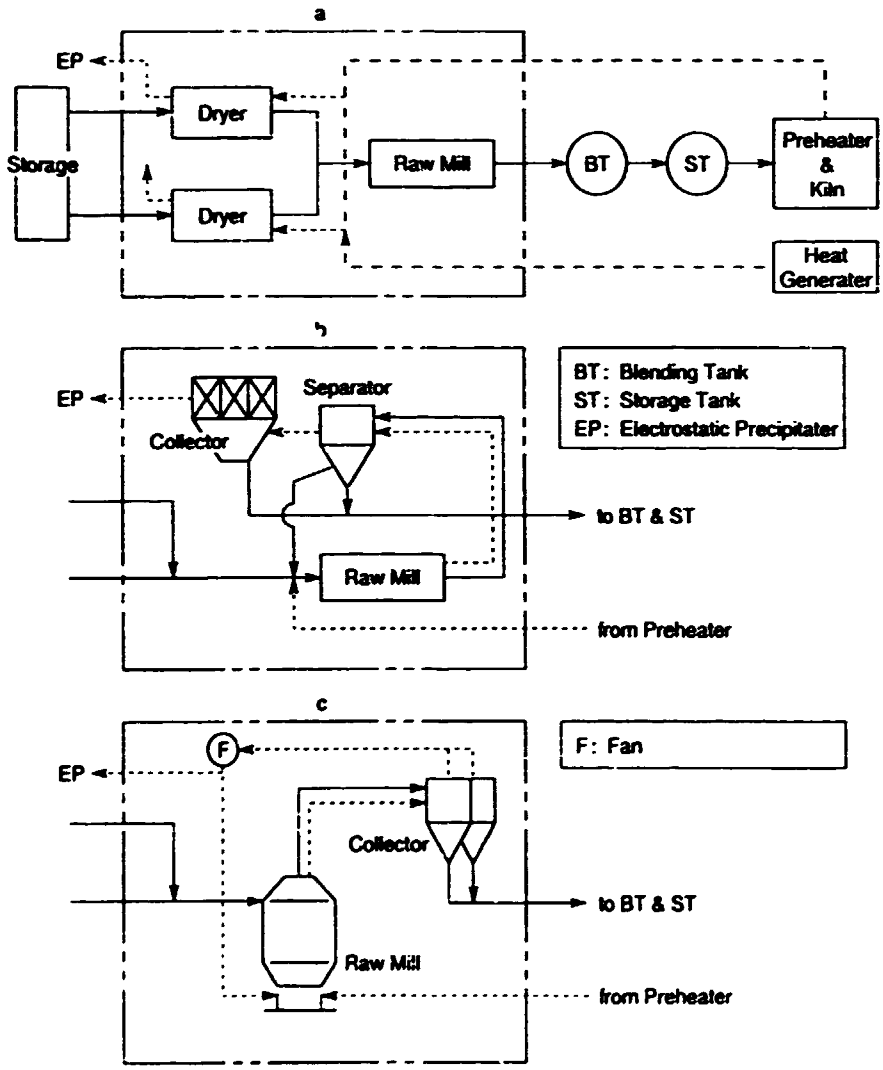


Figure 4 Dry process raw material grinding system

2.3 Clinker burning process

2.3.1 Wet process

A typical example of the wet process is a straight cylindrical type kiln having a length of about 40 times of the shell's inner diameter, which is generally known as a long economical kiln, installed with an inclination of 2.5 to 4% and slowly rotated at 0.5 to 1.5 rpm. Raw material is slurry containing 38 to 40% of water and fed from the upper end of the kiln, while fuel is blown in from the lower end of the kiln.

At the raw material inlet, a chain curtain zone is installed extending to 20 to 25% of the overall length to help dry the slurry. The hot clinker, which has been sintered in the kiln, is sent to the cooler and cooled down to 80 to 100°C. Hot air from the cooler is effectively used as the secondary air for combustion in the kiln.

Fig. 5 shows the temperature distribution in the kiln.

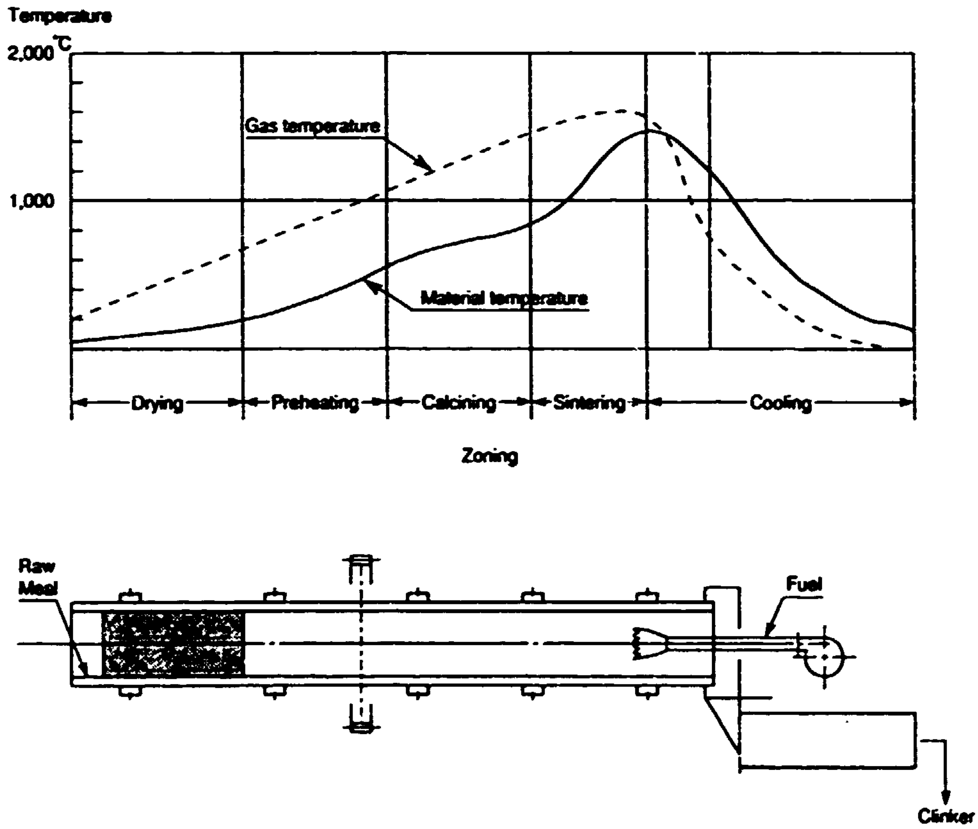


Figure 5 Temperature profile in wet process kiln

As obvious from the above figure, the wet process kiln has remarkable characteristics which allow four processes of drying the slurry, and preheating, calcining and sintering raw material collectively. Since the system is simple and easily operated, once the optimum operating condition is found, this condition can be easily retained stable. On the other hand, evaporation of about 40% of water of the slurry needs an extra heat value of about 400 kcal per kg of clinker. As a result, the largest consumption of fuel among all types of kilns is the disadvantage of the wet process kiln. As a countermeasure, a process of using a filter to dehydrate physically the raw material to a water content of 18 to 20% may be applied. In this case, however, since it is difficult to lower the kiln exhaust gas temperature to 500°C or below, another countermeasure such as using the remaining heat value for generation of electricity is needed. Therefore, the system becomes inevitably complex.

2.3.2 Semi-dry process

The semi-dry process is a special example of the dry process and uses a Lepol kiln or shaft kiln. In either kiln, the raw material ground in the dry process is shaped into pellets with diameter of 10 to 15 mm, so that about 13% of water is added.

In the case of the Lepol kiln, the pellets are dried and preheated once by the movable grate preheater shown in Fig. 6 and fed into the kiln. This system applies for the first time in the cement plant a concept of separating the raw material preheating process which used to be effected in the kiln and preheating by a separate device with high thermal efficiency. Then, the Lepol kiln has lost its position when a kiln with suspension preheater (SP kiln) was introduced but deserves special mention since it motivated energy conservation activity in the cement plants.

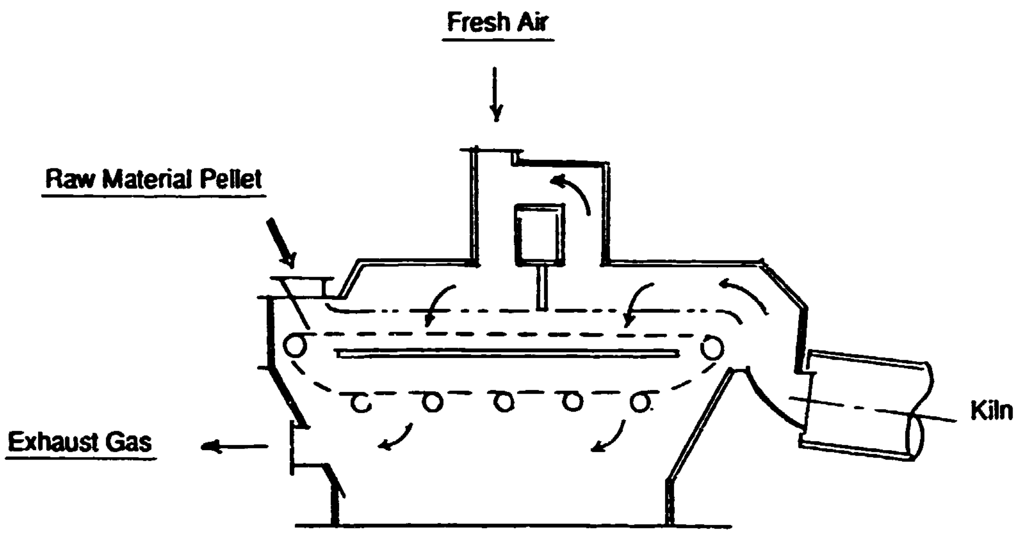


Figure 6 Grate preheater

In the shaft kiln, fuel (coke, oil coke or anthracite) is added in the pelletizing process. All processes of drying, sintering and cooling are effected in the vertical movable bed. This concept had been conducted before the rotary kiln was spread and, recently, as shown in Fig. 7, the shaft kiln with a continuous discharging function installed at the furnace bottom is mainly used in India and China. This kiln's advantage is heat economy but it also has disadvantages since the poking work in the furnace has to be repeated to retain a stable combustion state and nonuniformity of quality cannot be avoided.

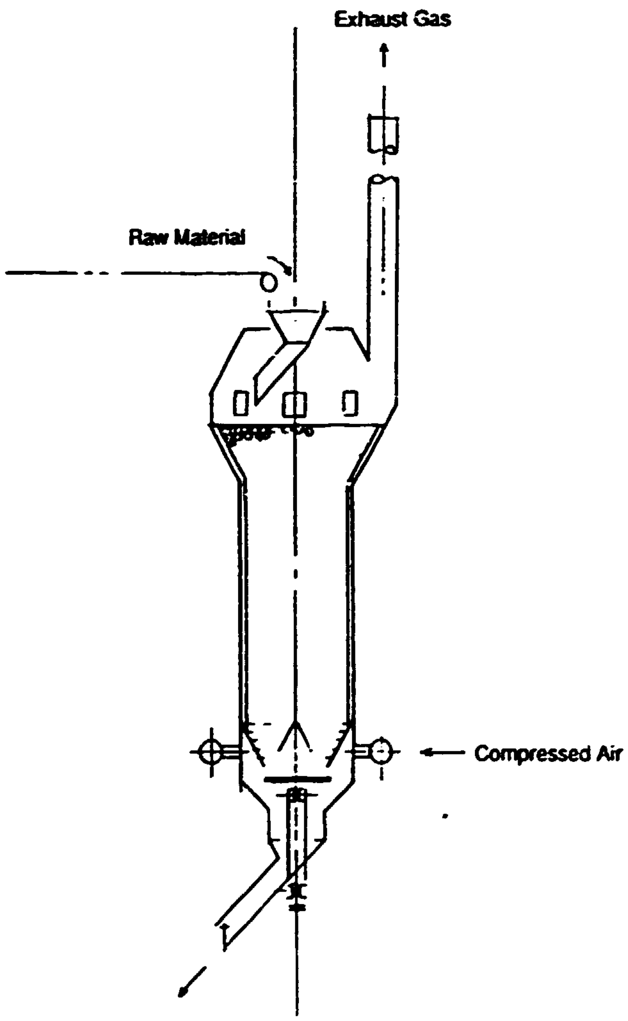


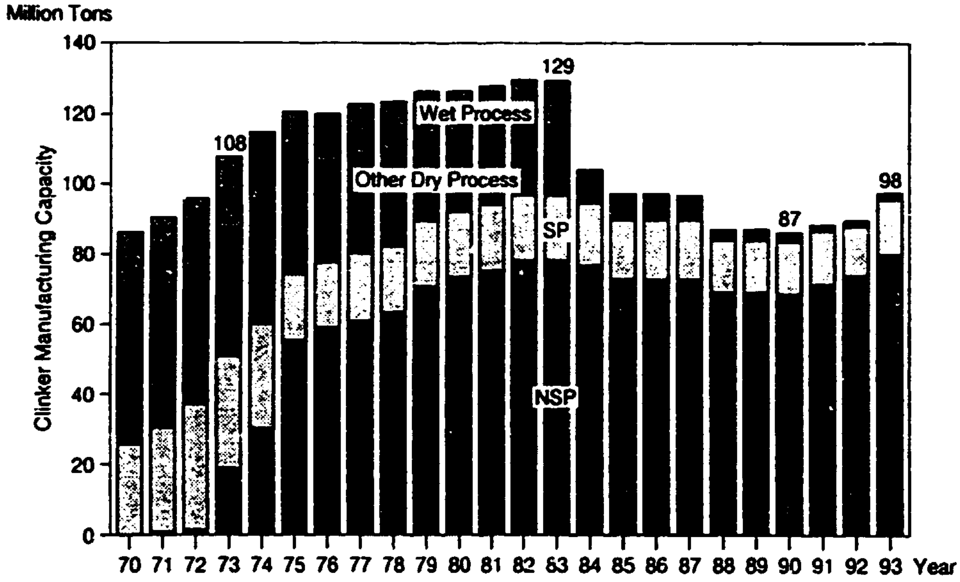
Figure 7 Shaft kiln

2.3.3 Dry process

In the dry process, there are the dry long kiln, the short kiln with boiler, the SP kiln and the NSP kiln.

The dry long kiln is mainly used in the Near and Middle East where rain falls less and alkaline components in raw material are large; its characteristics are similar to the wet process long kiln. In Southeast Asia, Central and South America, and North America, the wet process long kiln is mainly used.

Fig. 8 shows a transition of production systems in Japan. It can be seen that the wet process is rapidly replaced by the dry process. It reflects increasing needs for energy conservation and suggests what the true cement plant of the future should be.



Source: Cement in Japan 1993, JCA

Figure 8 Transition of clinker manufacturing capacity by type

A recent large NSP process has a heat consumption rate of about 750 kcal/kg-cl and is superior to all the conventional sintering processes.

In this connection, the wet process long kiln may have a heat consumption rate of 1,500 to 1,700 kcal/kg-cl except in some special cases, and the semi-dry process kiln may have 1,000 to 1,200 kcal/kg-cl.

Fig. 9 shows an SP kiln with 4-stage cyclone (dry process kiln with 4-stage cyclone preheater). Addition of a calciner in this figure will result in an example of NSP kiln. Generally, exhaust gas (350 to 380°C) from SP and NSP kilns is used to dry raw material (and to generate electricity) as shown in Fig. 10.

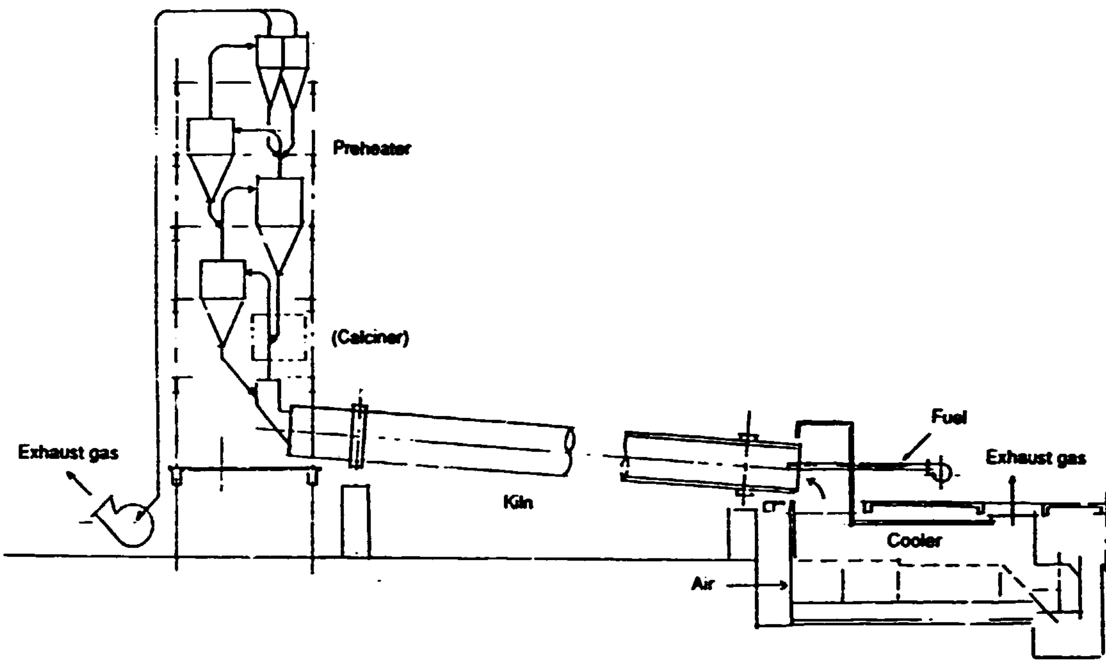


Figure 9 Dry process kiln with suspension preheater

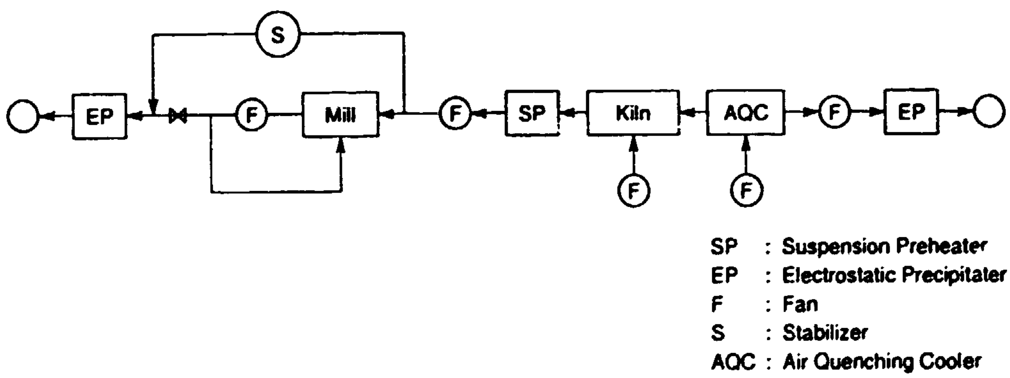


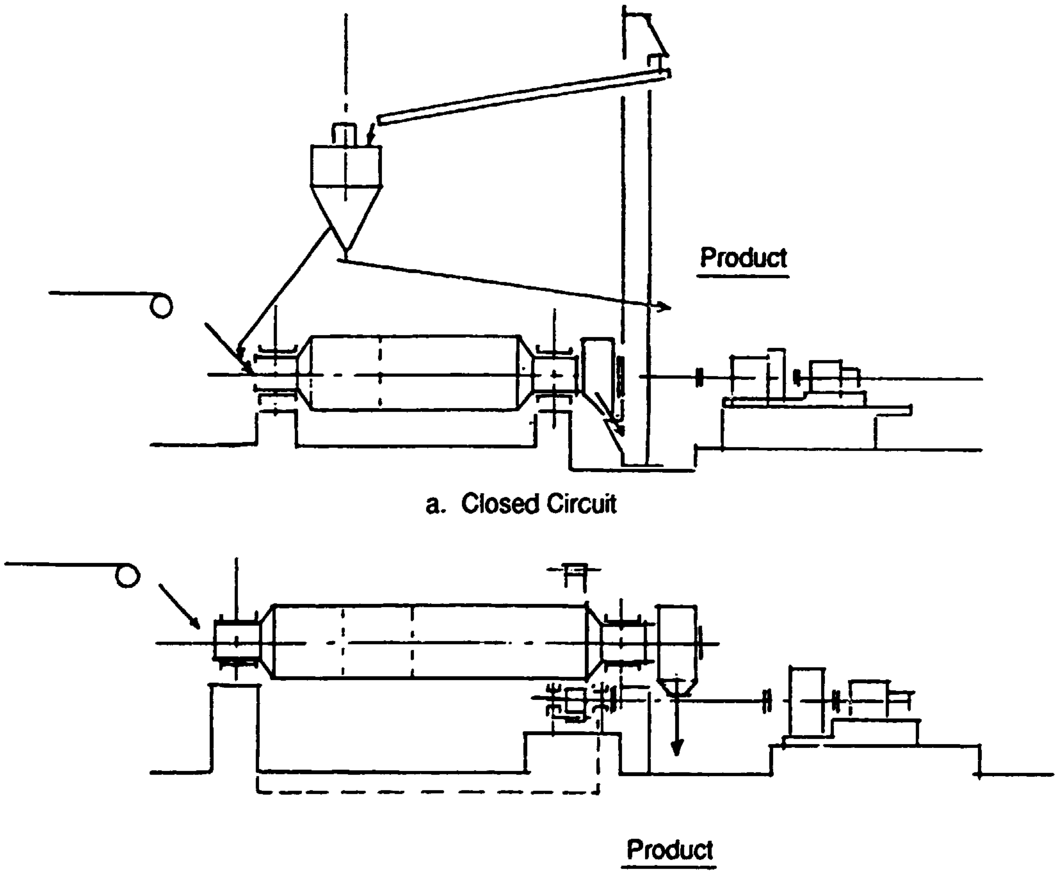
Figure 10 Gas flow diagram of SP kiln

2.4 Finish grinding process

The finish grinding process is roughly divided into an open circuit grinding system and a closed circuit grinding system. The mill used is a tube mill or ball mill. In Fig. 11, "a" shows a closed circuit and "b" shows an open circuit.

In the open circuit mill, the mill shell has a length of about 4 to 5 times of its diameter to obtain a prescribed fineness, and the shell outer wall is sprayed with water to prevent the temperature of the product in the mill from rising. It is also possible to spray water into the mill interior but the closest attention has to be paid so as not to deteriorate the product quality.

In the closed circuit mill, the mill has a length of 3 times or below of its diameter so as to accelerate the passage of the product. The separator works as a cooler for the product in addition to its function as classifier for the product.



a. Closed Circuit

b. Open Circuit

Figure 11 Clinker grinding system

3. Promotion of energy conservation technique

Energy conservation in industrial sectors starts from the software including operation control and process control, then extends into the field of hardware including equipment improvement and process improvement. Generally, energy conservation efforts can be classified into the following three steps:

Step 1 – Good housekeeping

Energy conservation efforts are made without much equipment investment, including elimination of the minor waste, review of the operation standards in the production line, more effective management, improvement of employees' cost consciousness, group activities, and improvement of operation technique.

For example, such efforts include management to prevent unnecessary lighting of the electric lamps and idle operation of the motors, repair of steam leakage, as well as reinforcement of heat insulations.

Step 2 – Equipment improvement

This is the phase of improving the energy efficiency of the equipment by minor modification of the existing production line to provide a waste heat recovery equipment and a gas pressure recovery equipment or by introduction of efficient energy conservation equipment, including replacement by advanced equipment. For example, energy conservation efforts in this step include an effective use of the waste heat recovery in combustion furnaces and introduction of the gas pressure recovery generator in the iron and steel works and waste heat recovery generator in cement plant.

Step 3 – Process improvement

This is intended to reduce energy consumption by substantial modification of the production process itself by technological development. Needless to say, this is accompanied by a large equipment investment. However, this is linked to modernization of the process aimed at energy conservation, high quality, higher added value, improved product yield and man power saving.

The energy conservation technique in the cement industry is classified as follows:

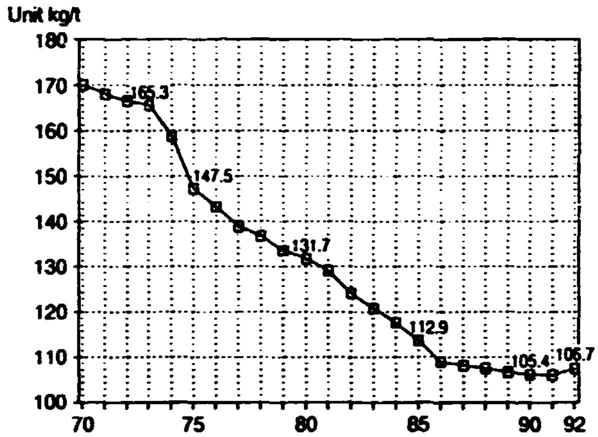
	Raw material process	Clinker burning process	Finish process
First step	1) Selection of raw material 2) Management of fineness 3) Management of optimum grinding media	1) Prevention of stop due to failure 2) Selection of fuel 3) Prevention of leak	1) Management of fineness 2) Management of optimum grinding media
Second step	1) Use of industrial waste material (fly ash) 2) Replacement of fan rotor 3) Improvement of temperature and pressure control system 4) Improvement of mixing & homogenizing system	1) Use of industrial waste material (waste tires) 2) Recovery of preheater exhaust gas 3) Recovery of cooler exhaust gas (drying of raw material and generation of electricity) 4) Replacement of cooler dust collector from multiclone to E.P.	1) Installation of closed circuit (dynamic separator) 2) Installation of feed control system
Third step	1) From wet process to dry process 2) From ball and tube mills to roller mill	1) From wet process to dry process 2) Conversion of fuel (from petroleum to coal) 3) From SP to NSP 4) Use of industrial waste (slag and pozzolan) 5) From planetary and under coolers to grate cooler	

3.1 Energy management

3.1.1 Energy consumption rate

Fig. 12, Fig. 13 and Fig. 14 show a change of energy consumption and energy consumption rate in all cement plants in Japan.

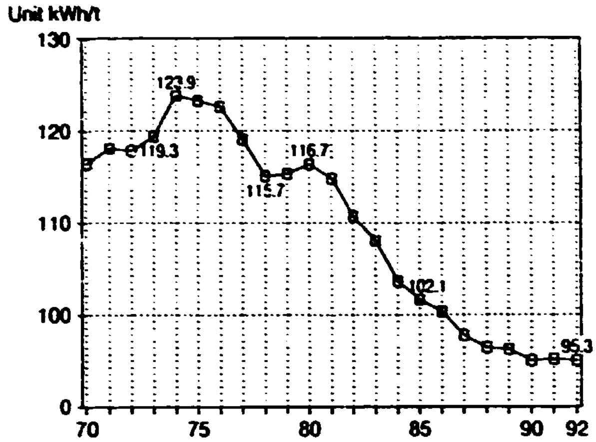
Comparing the period when the fuel consumption rate lowers sharply in Fig. 12 with Fig. 8, it coincides with the period when the NSP system was introduced. In the same period, the electric power consumption rate increases once and then continues to decrease, remaining stable for some period from 1978. In this period, fuel was changed from petroleum to coal. The improvement after that period may result from the active adoption of a roller mill as the raw material mill.



(Note) Consumption rate = Fuel consumption (excluding for generation of electricity)/ Cement production

Source: Cement in Japan 1993, JCA

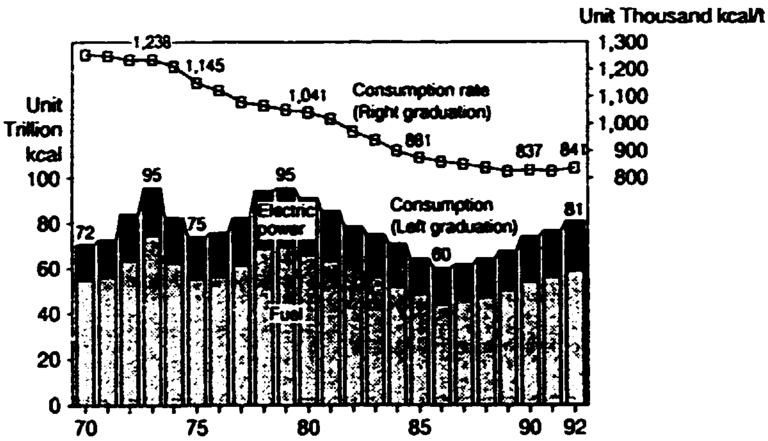
Figure 12 Change of fuel consumption rate (Coal (6,200 kcal/kg) conversion)



(Note) Consumption rate = Electric power consumption/
Cement production

Source: Cement in Japan 1993, JCA

Figure 13 Change of electric power consumption rate



(Note) 1. Total energy consumption= Fuel consumption (including for generation of electricity) × calorific value + purchased electric energy × 2,250 kcal/kWh

2. Total energy consumption rate= Total energy consumption/Cement production

Source: Cement in Japan 1993, JCA

Figure 14 Change of total energy consumption and consumption rate (Calorie conversion)

3.1.2 Analysis of operation condition

Improvements start with correct recognition of the present situation. The daily operation of the plant should be recorded in log sheets, which are routinely reviewed by the executives and compared with past data; if there is any abnormality, it should be immediately referred to the job site. Since part of the data which seems to be important is stored in the recorder, any problems concerning daily operation will mostly be solved by analyzing the data.

But, to further improve the present situation, such data are not sufficient and, therefore, more detailed measurement is made and the obtained results are collected in the form of a material balance and a heat balance. What is important is to review the results. Problems are highlighted by merely referring to the original design of the plant and the past measured results, and comparing with other similar plants. By simulating a little, the improvement effects can be predicted, and it can be judged whether the implementation should be made or not for the first time.

Table 3.1 shows the heat balance of 43 SP kilns and 8 NSP kilns.

Measurement does not require special techniques or equipment. But, since the temperature, pressure and flow rate are always variable during operation, a little skill and patience are required to keep the error up a minimum. Since it becomes necessary to set up a measuring point at a place different from the usual working place, consultation shall be held with a relevant party in advance taking the safety of work into consideration, and the measurement shall be made in cooperation with that party.

Readings of the instrument for operation shall not be adopted as the measured data as they are. Data for operation are sufficient as long as relative changes can be read but they do not always show absolute values correctly.

Table 1 Results of heat balance of all kilns (Mean value by kiln type)

Unit: 10^3 kcal/t-cl (percentage is given in parentheses)

Item	Type (Number of kilns)	SP kiln Deball (21)	SP kiln Funbolt (14)	SP kiln Pedarg (7)	SP kiln Smith (1)	SP kiln Total (43)	NSP kiln MFC (6)	NSP kiln SF (1)	NSP kiln KSV (1)	NSP kiln Total (8)
Thermal input	Combustion heat of heavy oil	(97.1) 816.7	(97.6) 828.9	(97.1) 785.3	(97.1) 782.0	(97.3) 814.8	(97.1) 787.6	(97.5) 806.1	(97.4) 789.1	(97.2) 790.1
	Other	(2.9) 24.3	(2.4) 20.6	(2.9) 23.4	(2.9) 23.1	(2.7) 23.0	(2.9) 23.1	(2.5) 20.5	(2.6) 21.4	(2.8) 22.6
	Total of heat input	(100.0) 841.0	(100.0) 849.5	(100.0) 809.2	(100.0) 805.1	(100.0) 837.8	(100.0) 810.7	(100.0) 826.6	(100.0) 810.5	(100.0) 812.7
Thermal output	Calorific value for clinker burning	(50.6) 425.9	(47.3) 401.1	(52.3) 423.1	(53.7) 432.9	(49.8) 417.5	(52.5) 425.9	(48.9) 403.4	(53.0) 429.2	(52.0) 423.5
	Sensible heat of preheater exhaust gas (including latent heat of evaporation of spray water)	(20.2) 169.5	(22.2) 188.6	(20.9) 169.1	(21.9) 176.1	(21.0) 175.8	(19.6) 158.5	(23.5) 194.1	(22.0) 178.4	(20.4) 165.4
	Calorific value taken away by clinker	(2.9) 24.0	(1.9) 16.4	(2.9) 23.2	(4.1) 33.3	(2.6) 21.6	(2.4) 19.4	(3.0) 25.0	(2.2) 18.0	(2.5) 19.9
	Sensible heat of cooler exhaust gas	(14.2) 119.4	(13.2) 112.3	(12.6) 102.2	(0) 0	(13.3) 111.5	(16.0) 129.9	(15.9) 131.7	(15.4) 125.1	(15.9) 129.5
	Heat loss by heat radiation etc.	(11.0) 92.2	(13.4) 114.0	(9.3) 75.1	(19.2) 154.3	(11.7) 98.0	(8.5) 68.6	(6.7) 55.7	(5.3) 43.2	(7.9) 63.8
	Others	(1.1) 10.0	(2.0) 17.1	(2.0) 16.5	(1.1) 8.5	(1.6) 13.3	(1.0) 8.4	(2.0) 76.7	(2.1) 16.6	(1.3) 10.5
	Total of heat output	(100.0) 841.0	(100.0) 849.5	(100.0) 809.2	(100.0) 805.1	(100.0) 837.8	(100.0) 810.7	(100.0) 826.6	(100.0) 810.5	(100.0) 812.6
Kiln efficiency (%)		51.1	47.0	52.2	53.5	50.0	52.6	48.6	52.4	52.1
Burning efficiency (%)		50.8	46.8	51.9	52.9	49.7	52.3	48.0	52.1	51.7

Table 2 shows the recording formats of heat balancing of the rotary kiln.

Table 2 Recording formats of heat balancing

(1) Outline of plant and equipment

Name of plant			
Location			
Kiln number			
Manufacturing method			
Kiln	Inside diameter	m	
	Full length	m	
Effective inside volume		m^3	
Kind of fuel used			
Type of burner	Kiln		
	Calcining furnace		
Cooler	Type		
	Size	m	
Suspension preheater	Type		
	Number of steps		
	Diameter of each step	m	
Calcining furnace	Type		
	Number of units		
	Diameter	m	
	Height	m	
	Effective inside volume	m^3	
Grate of Lepol preheater	Type		
	Length	m	
	Width	m	
History			
Remarks			

(2) Measurement items

Measurement period (time and date)	(hours)			
Name of measuring person(s)				
Climate	Atmospheric pressure Pa (mmHg)	Wind velocity m/s	Outside air temperature °C	Outside air humidity (relative humidity) %

Item				Measured value	Number of times of measurements	Remarks
Clinker	Output		t/h			
	Compo-sition	SiO_2	%			
		Al_2O_3	%			
		Fe_2O_3	%			
		CaO	%			
		MgO	%			
	Lime saturation (L.S.D.)					
	Temper-ature	At cooler entrance	°C			
		At cooler exit	°C			
Volume of exhaust gas emanating from dry materials		Steam	m^3_N/t clinker			
		Carbon dioxide	m^3_N/t clinker			
Materials	Used quantity		kg/t clinker			
	Water content		%			
	Temperature		°C			
	Low heat value		kJ/kg (kcal/kg)			
Fuel	Kind					
	Brand					
	Compo-sition (at use)		%			
			%			
			%			
			%			
			%			
			%			
			%			
			%			
			%			
			%			
			%			
	High heat value		kJ/kg (kcal/kg)			
	Low heat value		kJ/kg (kcal/kg)			
	Temperature		°C			

Fuel	Used quantity		Kiln	kg/t clinker			
			Calcining furnace	kg/t clinker			
			Total	kg/t clinker			
Air for combustion	Primary air	Kiln	Volume	m^3N/t clinker			
			Temperature	°C			
			Pressure	Pa (mmAq)			
		Calcining furnace	Volume	m^3N/t clinker			
			Temperature	°C			
			Pressure	Pa (mmAq)			
	Secondary air	Kiln	Volume	m^3N/t clinker			
			Temperature	°C			
		Calcining furnace	Volume	m^3N/t clinker			
			Temperature	°C			
Exhaust gas from kiln	Volume			m^3N/t clinker			
	Temperature			°C			
	Pressure			Pa (mmAq)			
	Composition		CO_2	%			
			O_2	%			
			CO	%			
			N_2	%			
	Air ratio						
Exhaust gas at preheater exit	Volume			m^3N/t clinker			
	Temperature			°C			
	Pressure			Pa (mmAq)			
	Composition		CO_2	%			
			O_2	%			
			CO	%			
			N_2	%			
	Air ratio						
Cooling air of cooler			Volume	m^3N/t clinker			
			Temperature	°C			
Exhaust from cooler			Volume	m^3N/t clinker			
			Temperature	°C			
Dust scattering at preheater or kiln exit			Mass	t/t clinker			
			Temperature	°C			
Remarks							

(3) Table of heat balancing

(3-1) Kiln

Item		10^3 kJ/t clinker (10^3 kcal/t clinker)	%
Thermal input Q_1	(1) Heat of combustion of fuel Q_a		
	(2) Sensible heat of fuel Q_b		
	(3) Heat of combustion of materials Q_c		
	(4) Sensible heat of materials Q_d		
	(a) Sensible heat of dry materials		
	(b) Sensible heat of water content in materials		
	(5) Sensible heat of primary air Q_e		
	(6) Sensible heat of cooling air of cooler Q_f		
	Total		
Thermal output Q_2	(7) Heat for clinkering Q_g		
	(8) (Sensible heat of clinker entering cooler) Q_h	( )	( )
	(9) Sensible heat taken away by clinker Q_i		
	(10) Sensible heat taken away by exhaust from cooler Q_j		
	(11) Heat of vaporization of water content in materials Q_k		
	(12) Sensible heat taken awa by exhaust gas from preheater or kiln Q_l		
	(a) Sensible heat of steam emanating from materials		
	(b) Sensible heat of carbon dioxide emanating from materials		
	(c) Sensible heat of combustion gas		
	(13) Sensible heat taken away by dust Q_m		
	(14) Heat lost due to radiation, and the like Q_n		
	Total		
Burning efficiency η_f			%
Circulating heat Q_3	(15) Heat recovered by primary air Q_o		
	(16) Heat recovered by second air and extracted air from cooler for calcining furnace Q_p		
	(17) Heat recovered by cooling air of cooler Q_q		

Remarks: The numerical values in ( ) should not be summed together.

(3-2) Cooler

Item		10^3 kJ/t clinker (10^3 kcal/t clinker)	%
Thermal input Q_d	(1) Sensible heat of clinker entering cooler Q_a		
	(2) Sensible heat of cooling air Q_f		
	Total		
Thermal output Q_s	(3) Sensible heat by secondary air of kiln and extracted air from cooler for calcining furnace Q_p		
	(a) Sensible heat by secondary air of kiln Q_{pk}		
	(b) Sensible heat by extracted air from cooler for calcining furnace Q_{pw}		
	(4) Sensible heat taken away by clinker Q_i		
	(5) Sensible heat taken away by exhaust from cooler Q_j		
	(6) Sensible heat taken away by extracted air from cooler for other than calcining furnace Q_w		
	(7) Heat lost due to radiation, etc. Q_k		
	Total		
Recovery efficiency by secondary air η_c		%	
Circulating heat Q_h	(8) Heat recovering by cooling air of cooler Q_c		

(3.3) Utilization of exhaust gas

Item	Utilization or nonutilization	Purpose for utilization
Exhaust from preheater or kiln		
Exhaust from cooler		

3.1.3 Establishment of operation manual

It is needless to say that the attainment of a stable operation at a high level is an essential condition to obtain a profit for a cement plant which consumes a large volume of energy.

A system of calculating loss resulting from the shutdown due to a failure is different depending on the situation of a plant and the market environment. For example, the following calculation can be made.

When

the rated capacity of plant: 500 [t/day]

the time required for one recovery: 12 [hrs]

the idle time and output reduction rate in the above time: 50 [%],

then,

1. Energy loss (energy cost 15.5$/t)
   15.5 [$/t] × (12/24) × 500 [t] × 50 [%] = 1,938 $
2. Lost profits due to output reduction
   (supposing a marginal profit is 29.5 $/t)
   29.5 [$/t] × (12/24) × 500 [t] × 50 [%] = 3,687 $

hence total of 1 and 2 above is 5,625 $.

If recovery is made appropriately, the loss may be less but, if a secondary accident such as the breaking of bricks is caused, the loss may be higher. Recovery takes a longer time as the facilities become larger. For thorough preventive maintenance and improvement of morale of employees to prevent the shutdown due to a failure, expenses needed therefor shall not be spared.

As material for technical training of employees, the operation manual and maintenance manual provided by the equipment supplier can be used. But, such manuals are generally limited to describe the operation procedure of a process and the disassembling and assembling procedures of equipment. A method for optimum operation or preventive maintenance has to be found by the user. Ideally, such manuals are drawn up through a group activity (TQC) of engineers or foremen in a company. It is not necessary to stick to the style of manuals and the quality of the contents. What is important is that the persons concerned have an interest in such an activity.

It is certain that the will to conserve energy does not occur when a stable operation cannot be continued. For the time being, if an appropriate leader is not available, a well-experienced cement expert or consultant shall be asked for cooperation to draw up such a manual urgently. Costs for that purpose will be recovered easily.

3.1.4 Choice of raw material and fuel

After the commissioning time of the plant and the removal of various uncertain factors, the supply source of raw material can be reviewed. By expansion of the stock yard or the adoption of a preblending system, there are a number of possibilities that inexpensive raw material with low purity or substitute raw material excelling in grindability and/or burnability will be found. When a computer is used to control the process for blending or mixing raw materials, it displays its great power in stabilizing the process and conserving energy beyond its role for foolproof.

Table 3 shows the state of using industrial wastes or by-products in the cement industry in Japan.

Table 3 Used amount of industrial wastes and by-products in the cement industry

(Unit: t,%)

Kind \ Year	1991	1992	
			Ratio to the previous year
Blast furnace slag	13,498,066	13,554,903	100.4
Converter slag	1,269,871	1,132,305	89.2
Coal ash	2,382,745	2,545,398	106.8
By-product gypsum	2,216,436	2,212,486	99.8
Debris	1,807,455	1,880,149	104.0
Non-ferrous slag	1,415,723	1,368,606	96.7
Sludge	532,525	622,334	116.9
Unburnt ash and dust	439,096	474,724	108.1
Molding sand	294,435	298,082	101.2
Waste tire	127,084	170,819	134.4
Waste oil and reclaimed oil	138,792	168,418	121.3
Waste China clay	36,855	34,633	94.0
Other	256,024	245,369	95.8
Total	24,415,107	24,708,226	101.2

Source: Japan Cement Association

Mixing of blast furnace slag, pozzolan and fly ash contributes largely to energy conservation in view of the cement base. Japanese Industrial Standard (JIS) provides quality standards to three different mixing ratios as shown in Table 4. To meet such standards, both mixtures and host cement have to be strictly controlled for quality. In this sense, quality control is a first step for energy conservation.

Table 4 JIS specification for cement

Type of cement	Chemical composition (%)					Mineral composition (%)		Heat of hydration (cal/g) (J/g)		Fineness specific surface (Blaine method) (cm^2/g)	Time of setting			Compressive strength (kgf/cm^2) (N/mm^2)			
	Ig loss	SO_3	MgO	Alkalies	Cl	C_3S	C_3A	7 days	28 days		Initial (min)	Final (hr)	Soundness	1 day	3 days	7 days	28 days
Portland cement																	
Ordinary	≤ 3.0	≤ 3.0	≤ 5.0	≤ 0.75	≤ 0.02					≥ 2,500	≥ 60	≤ 10	Good		≥ 70(6 86)	≥ 150(14 71)	≥ 300(29 42)
High early strength	≤ 3.0	≤ 3.5	≤ 5.0	≤ 0.75	≤ 0.02					≥ 3,300	≥ 45	≤ 10	Good	≥ 65(6 37)	≥ 130(12 75)	≥ 230(22 56)	≥ 330(32 36)
Super-high early strength	≤ 3.0	≤ 4.5	≤ 5.0	≤ 0.75	≤ 0.02					≥ 4,000	≥ 45	≤ 10	Good	≥ 130(12 75)	≥ 200(19 61)	≥ 280(27 46)	≥ 350(34 32)
Moderate heat	≤ 3.0	≤ 3.0	≤ 5.0	≤ 0.75	≤ 0.02	≤ 50	≤ 8	≤ 70(293)	≤ 83(347)	≥ 2,500	≥ 60	≤ 10	Good		≥ 50(4 90)	≥ 100(9 81)	≥ 230(22 56)
Sulphate resisting	≤ 3.0	≤ 3.0	≤ 5.0	≤ 0.75	≤ 0.02		≤ 4			≥ 2,500	≥ 60	≤ 10	Good		≥ 70(6 86)	≥ 140(3 73)	≥ 280(27 46)
Portland blast furnace slag cement																	
Class A	≤ 3.0	≤ 3.5	≤ 5.0							≥ 3,000	≥ 60	≤ 10	Good		≥ 70(6 86)	≥ 150(14 71)	≥ 300(29 42)
Class B	≤ 3.0	≤ 4.0	≤ 6.0							≥ 3,000	≥ 60	≤ 10	Good		≥ 60(5 88)	≥ 120(11 77)	≥ 290(28 44)
Class C	≤ 3.0	≤ 4.5	≤ 6.0							≥ 3,300	≥ 60	≤ 10	Good		≥ 50(4 90)	≥ 100(9 81)	≥ 280(27 46)
Portland pozzolan cement																	
Class A	≤ 3.0	≤ 3.0	≤ 5.0							≥ 3,000	≥ 60	≤ 10	Good		≥ 70(6 86)	≥ 150(14 71)	≥ 300(29 42)
Class B		≤ 3.0	≤ 5.0							≥ 3,000	≥ 60	≤ 10	Good		≥ 60(5 88)	≥ 120(11 77)	≥ 260(25 50)
Class C		≤ 3.0	≤ 5.0							≥ 3,300	≥ 60	≤ 10	Good		≥ 50(4 90)	≥ 100(9 81)	≥ 210(20 59)
Portland fly-ash cement																	
Class A	≤ 3.0	≤ 3.0	≤ 5.0							≥ 2,500	≥ 60	≤ 10	Good		≥ 70(6 86)	≥ 150(14 71)	≥ 300(29 42)
Class B		≤ 3.0	≤ 5.0							≥ 2,500	≥ 60	≤ 10	Good		≥ 60(5 88)	≥ 120(11 77)	≥ 260(25 50)
Class C		≤ 3.0	≤ 5.0							≥ 2,500	≥ 60	≤ 10	Good		≥ 50(4 90)	≥ 100(9 81)	≥ 210(20 59)

(Note) 1) Ordinary portland cement can be blended either uniformly with blast-furnace slag, pozzolan, fly-ash, and lime stone, or the pozzolan whose total content is less than 5% of the gross weight.

2) Total alkali content (%) of portland cement (low alkali type) shall not be more than 0.6%.

3) Proportion of Admixture for Blended Cement as follows:

Type	Volume of blast furnace slag (W/%)	Volume pozzolan (W/%)	Volume of fly-ash (W/%)
A	> 5 ≤ 30	> 5 ≤ 10	> 5 ≤ 10
B	> 30 ≤ 60	> 10 ≤ 20	> 10 ≤ 20
C	> 60 ≤ 70	> 20 ≤ 30	> 20 ≤ 30

4) Values in Parentheses are indicated by SI unit

5) Alkalies (%) = Na_2O(%) + 0.658K_2O(%)

6) Strength tests

<Sand for strength tests>

Natural sand, max. 1% retained on sieve with apertures 297μ, and min. 95% retained on sieve with apertures 105μ.

<Preparation of specimens for bending and compressive strength tests>

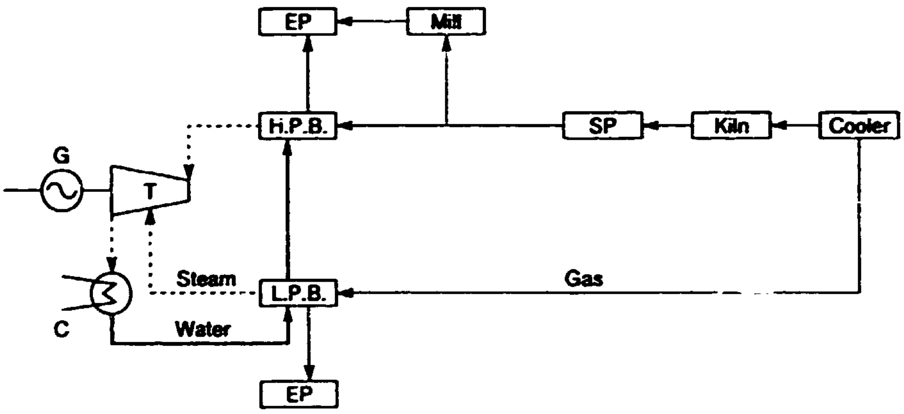
Specimens 40 × 40 × 160 mm Min proportion of cement to sand 1.2, water/cement ratio 0 6.5 Compressive strength test on broken prisms from bending strength test.

Generally, natural gas, heavy oil and coal are used as fuel. In Japan, the fuel was changed from heavy oil to coal around 1980 with the occurrence of the second oil crisis as seen in Fig. 18. Currently, consumption of heavy oil is only about 1% of coal. The change from heavy oil to coal is being carried out not only in Japan but also in petropowers such as Indonesia and Malaysia. From the waste tires (840,000 tons) produced in 1992 in Japan, 20.1% was used for sintering of cement. Various substitute fuels may be found, depending on regions.

3.1.5 Waste heat recovery power generation

Table 1 shows that the preheater exhaust gas has about 20% of the heating value brought in by the fuel and the cooler exhaust gas has about 14%. These residual heating values can be used to dry raw materials and to generate electricity. In Japanese cement plants, 19 power plants utilizing waste heat are operating and, including independent power plants, 41.8% of all electric power consumed in the cement plants is provided by private power plants as shown in Fig. 2. Fig. 15 shows a flow diagram of such plants.

The private power generating system is adopted on the assumption that the running cost is lower than the purchased power unit price. If the finish mill has surplus capacity, however, it can lower a load in a daytime power demand time zone and raise a nighttime load factor and, in addition, brings about advantages such as to avoid shutdown due to extrinsic factors and to improve the kiln's operation rate.



H.P.B. : High Pressure Boiler
L.P.M. : Low Pressure Boiler
T : Turbine
G : Generator
C : Condenser
SP : Suspension Preheater
EP : Electrostatic Precipitater

Figure 15 Waste heat recovery power generation

3.1.6 Equipment investment

Fig. 16, Fig. 17, Fig. 18 and Table 5 show that the energy conservation measures in Japan have been timely taken, keeping pace with measures to enhance the production capacity and to improve the labor productivity. When an investment is made not only with a view to energy conservation but in such a way as to produce combined effects including the increase of production and the stabilization of operation, advantages are large and invested capital is recovered earlier.

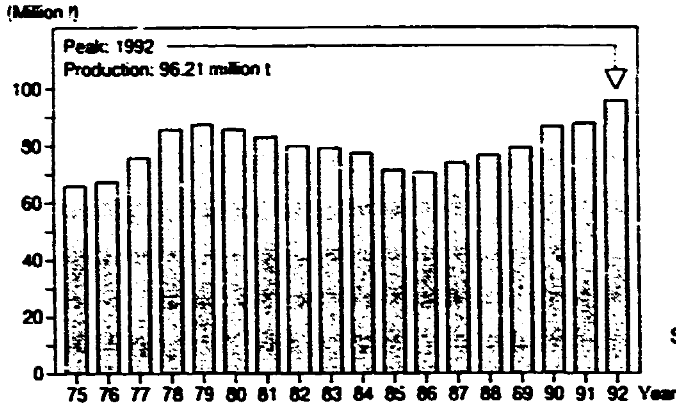
Since an investment for renovation is indispensable for the cement industry, which is a process industry, to survive, there is always a chance to improve facilities for energy conservation and, company management should always be ready to raise funds so as not to miss the best timing. Middle management and engineers have to provide up-to-date information to support the top management making a decision.

Table 5 Rationalization in cement manufacturing

FY	Company	Plant	Kiln	Kiln capacity (1,000 tons)	Silo capacity (1,000 tons)	Productoin worker	Production* per worker (tons)	Energy use [1,000 kcal / ton cement]
1970	22	58	226	86,449	1,711	16,549	3,316	1,254
1975	22	58	246	120,763	2,743	14,774	4,275	1,146
1980	24	53	192	126,352	3,689	10,830	7,965	1,041
1985	22	44	98	97,981	4,205	8,617	8,207	881
1990	23	41	80	87,175	4,360	6,949	10,834	837
1992	22	41	81	90,467	4,446	7,014	12,459	841

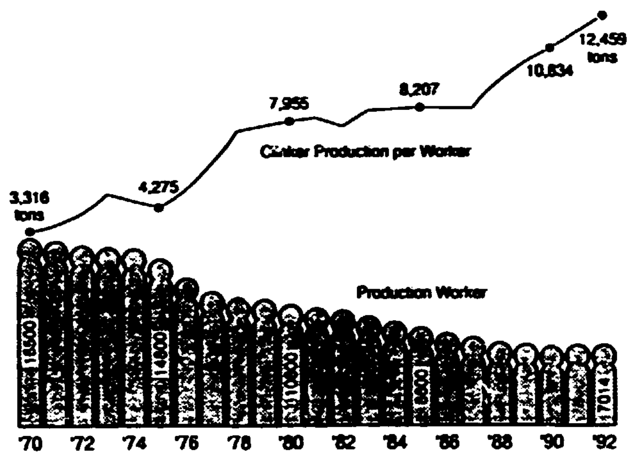
Note: * Calendar year base.

Source: Cement in Japan 1993, JCA



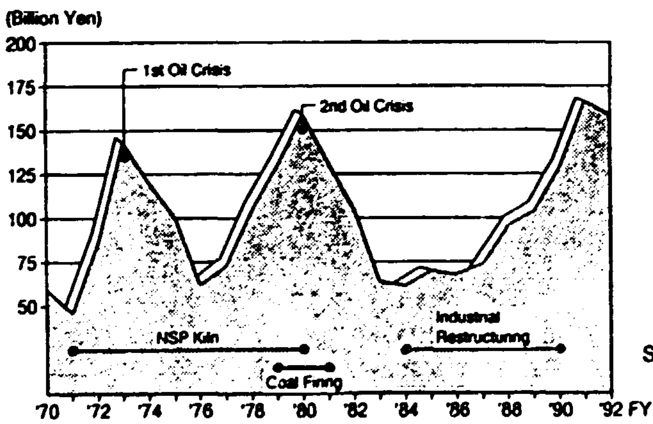
Source: Cement in Japan 1993, JCA

Figure 16 Change in cement production



Source: Cement in Japan 1993, JCA

Figure 17 Labor productivity



Source: Cement in Japan 1993, JCA

Figure 18 Machinery and equipment investment

3.2 Energy conservation technique in cement production process

3.2.1 Raw mill

Since the wet process has a simple system, it is important to enhance the operation efficiency of the mill itself. The mill performance depends on various factors. And, among them, the basic items are given by the following empirical formulas, for example.

Bond's third theory:

$$W = 10\,wi\left(\frac{1}{\sqrt{P}} - \frac{1}{\sqrt{F}}\right) \quad \cdots\cdots (1)$$

where,

w = kwh per short ton of grinding material

F = microns 80% of the feed passing

P = microns 80% of the product passing

wi = work index according to Bond's test mill

Critical mill speed:

$$n = \leq \frac{32}{\sqrt{Di}} \quad \cdots\cdots (2)$$

Mill drive power:

$$N = C \cdot G \cdot Di \cdot n \quad \cdots\cdots (3)$$

where,

N = power consumption [kw]

G = weight of mill charge [t]

Di = internal diameter of mill [m]

n = speed of mill rotation [r/m]

C = power factor of Fig. 19

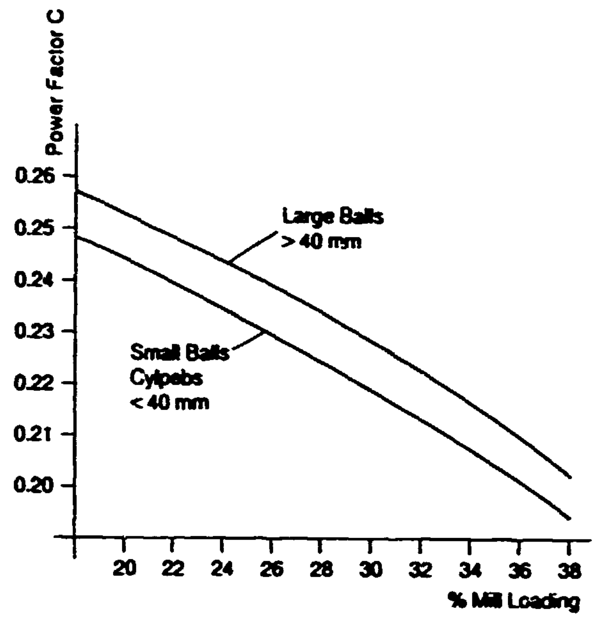


Figure 19 Power factor C for determining the drive power of a tube mill

The selection of appropriate ball size, ball charge amount in each chamber and many other hints are given in "Cement Engineers' Handbook" (Labohm and others, Bauverlag Gmbh, Wiesbaden) and "Cement-Data-Book" (Duda, Macdonald & Evans, London), for example.

Generally, mill suppliers design systems having precision which seems to be almost appropriate based on the test results of a given material sample, so that they can be appropriately adjusted at the actual location. But, as time passes, properties of raw material continue to change. Therefore, the optimum point of operation is to be finally decided by the user based on a trial at the actual location.

If the capacity lowers as the operation progresses, the work index wi or feed size F in the formula (1) shall be doubted first. When the value F is larger than the planned value, one of the solutions is to increase the size of the balls in the first chamber but, a better solution is to service or adjust the preceding crusher process to decrease the feed size. If the product becomes coarse or the the value P of the formula (1) becomes large, it shall be checked first that the ball charge amount is lowered due to abrasion. The formula (1) was originally derived from the closed circuit system of the dry process but, it can also be applied to the wet process mill by adopting an appropriate conversion factor. In the wet process, since the ball surface is always washed with water, the grinding efficiency is 20 to 30% higher than in the dry process mill but the abrasion loss of the balls and lining is much larger.

The decrease of balls due to abrasion appears as a decrease of the motor load but, as it is seen from Fig. 17, the relation between them is not linear. By measuring several times at intervals of two to three months, an abrasion characteristic value of each mill can be seized. After this, depending on the operation time or the output, replenishment shall be made periodically to keep an appropriate charge.

Excessive grinding should be avoided to save power consumption, regardless of the type of process, dry or wet. Recent operation experience with an SP or NSP kiln reveals that even though the residue on 88 μ sieve increases up to 13 or 15%, it does not seem to have any actual adverse effect on the burnability in the sintering process, as far as the rough grain is composed of $CaCO_3$. When the clay in the material has a rather grindable property, or when it is composed only of fine grains, as is sometimes seen in the wet process, it will be advisable to set the target fineness value higher. This measure may result in an about 3 to 5% electric power conservation. Mixing of fly ash or pozzolan as the substitute material for clay will attain the same result, if its grain degree is fine.

In the case of the dry process mill, in addition to the efficiency of the mill, two problems of improving heat economical efficiency and lowering fan power have to be solved. As the heat source for drying raw materials, the preheater exhaust gas is generally used as shown in Fig. 23. According to Table 1, this exhaust gas has a calorific value of about 170 kcal for 1 kg of clinker, so that this gas is theoretically sufficient to dry about 10% of water in the combined raw materials. Therefore, a more significant issue is to lower the power consumption.

Recently, the spread of the roller mill shown in Fig. 4, c, makes a great contribution to the reduction of power consumption in this process. To dry and grind at the same time, this process flows a large volume of gas through the system, increasing the power consumed by the fan. Therefore, the difference of the facility power of the mill itself is not related to the reduction of electric power but, as compared to the existing process with the ball mill, reduces the power consumption by 10 to 15%. More reduction can be expected by reducing of the volume of gas passing through or circulating in the process.

3.2.2 Kiln and preheater

As shown in Fig. 8, the cement burning process in Japan was rapidly changed from the wet process to the NSP process and, accordingly, the heat consumption rate was remarkably improved.

Fig. 20 shows typical examples of the precalciner used in Japan.

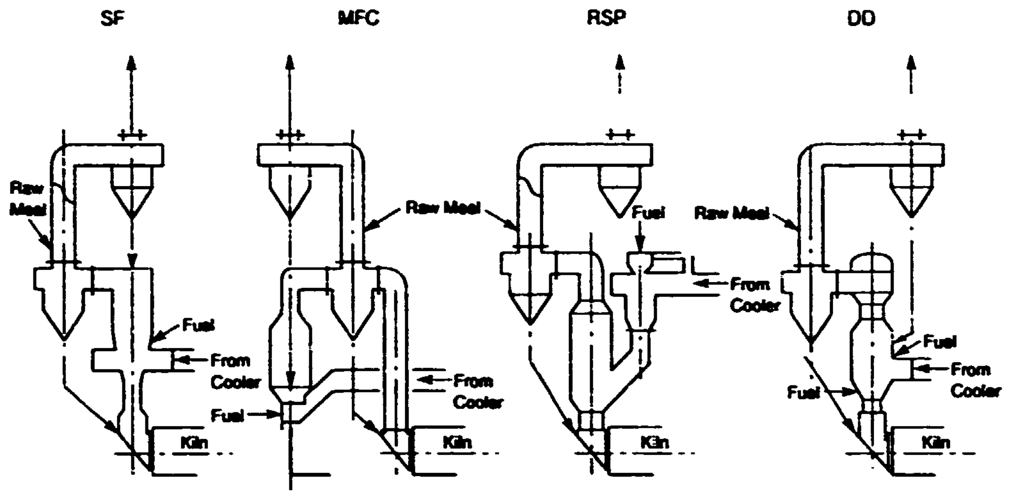


Figure 20 Calciners

Fig. 21 shows the clinker burning process of the NSP system with the values of Table 1 slightly rounded up. It will be understood that most of the required heat value is consumed to decompose $CaCO_3$ and most of the heat value is directly supplied to the precalciner. Consequently, in the NSP system, the kiln's heat load is greatly reduced and the precalcining process can be freely controlled regardless of the state of the kiln.

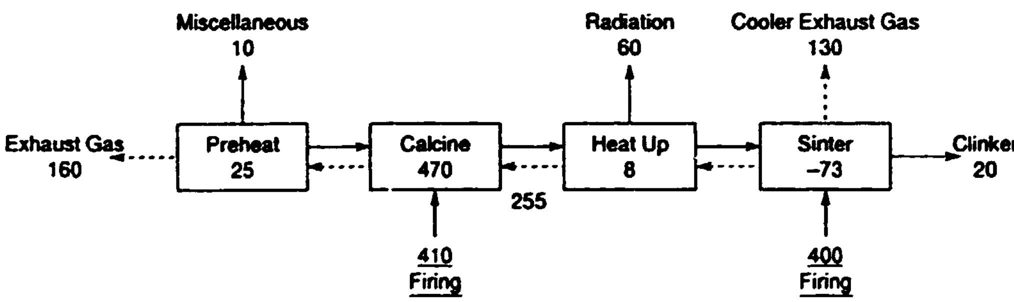


Figure 21 Typical heat balance model of burning process (Unit: kcal/kg clinker)

Originally, the NSP system was developed for a large capacity kiln to make the kiln size small. Therefore, there are some misunderstandings but, since the aforementioned remarkable mechanism has unexpected advantages such as suppression of the generation of NOx, the NSP system should be actively adopted for a small capacity kiln.

Generally, the cyclone has a large ventilation resistance and usually accompanies a pressure loss of 100 to 150 mmAq. A preheater with this cyclone piled up in 4 or 5 stages consumes much power, which constitutes one of the disadvantages of the SP or NSP system. But, it is not preferable to lower the pressure loss at the expense of the separation efficiency of the cyclone. The lowering of the efficiency increases the circulating amount of raw material and raises the cyclone outlet temperature, resulting in merely increasing the heat loss and not leading to improvement.

Preventing the leakage air from flowing into the process is important for all processes, and the preheater is not an exception. As shown in Fig. 22, when simulation is made using one section of the preheater as a model, mixing of a leakage amount of 10% results in a loss of 18 kcal/kgcl. When a loss due to the increase of the exhaust gas amount or decrease of output is added, the total losses are larger. Leakage prevention measures have to be taken from both aspects of improving facilities and training the operator.

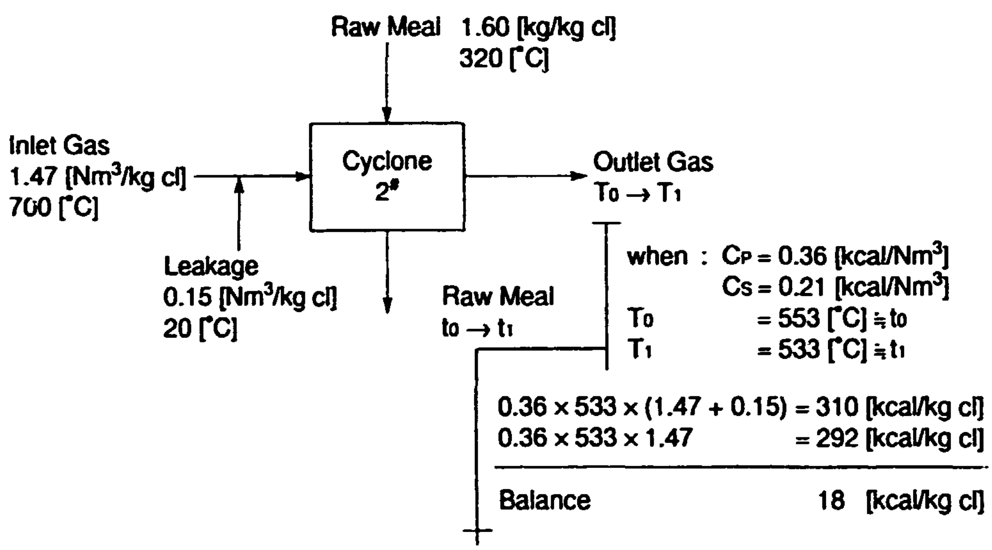


Figure 22 Effect of leakage air

The inspection and cleaning ports which are frequently opened or closed during operation should be modified to the size and structure suitable for the situation at site so as to allow a quick and appropriate operation. In addition, workers should be strictly told to close the port tightly upon completion of operation. Leaks from manholes, etc. not so frequently subjected to opening/closing are, in many cases, detected after starting of operation through air inhaling, sound or gas analysis. It will be necessary to make it a custom to fill a sealing or coking material to provide sealing as often as required. Also it is recommendable to weld flanges and joints installed for the convenience of assembly, if a leak has occurred. In many cases, the movable sections at both edges of the kiln allow much leak due to clearances arising from deformation by heating and wear. The leaks from these sections lead directly to a reduction in the output of the kiln. After repair, comparison of operation data should be made.

3.2.3 Air quenching cooler

Regardless of the type, the clinker cooler is installed to improve the product quality by quenching the clinker. But, it also functions to recover the heat retained by the clinker which was red-heated, by preheating the secondary air for combustion. From this point of view, the grate cooler is superior to the planetary cooler or under cooler because the secondary air temperature can be controlled.

According to the "heat balance" of Table 1, the cooler exhaust gas retains a calorific value of 13 to 16% of total consumption of calorific value and, when the heat efficiency of the kiln and preheater is improved, the required amount of the secondary air used for combustion is lowered and the cooler exhaust gas amount increases, resulting in a substantial increase in loss. As a countermeasure, it is necessary to increase the layer thickness of the clinker on the grate cooler to improve the heat-exchange efficiency.

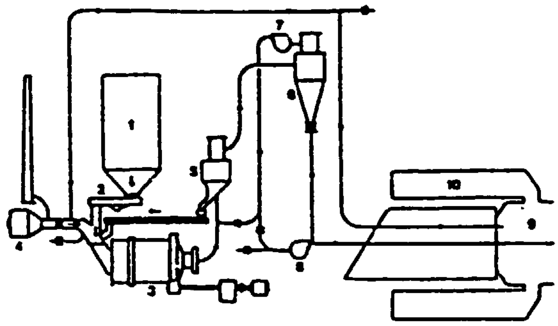
3.2.4 Coal mill

For drying and grinding of coal and feeding to the kiln, the following three systems are employed as shown in Fig. 23.

a. Direct firing
b. Semi-direct firing
c. Indirect firing

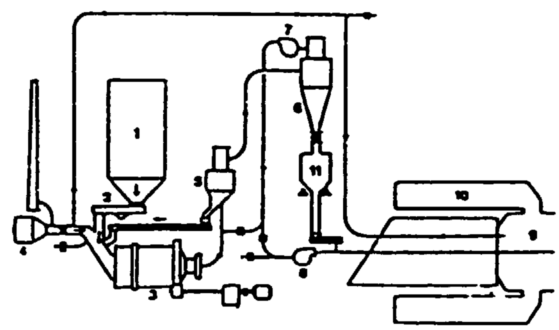
Among the above systems, the direct firing system is extensively used because its equipment is simple, construction cost is low and operation is simple. But, for purposes of accurately controlling the feed amount to the kiln and limiting the primary air volume to the minimum, the indirect firing system is most preferable. It is possible to remodel the system "a" into the system "c". But, it is necessary to pay special attention to prevent spontaneous combustion and explosion of coal powder.

A mill type in popular use is either a single barrel air swept mill or a roller mill.



Notation:
1 Raw Coal Silo
2 Weigh Belt Feeder
3 Air-swept Ball Mill (Tirax-mill)
4 Air Heater (Auxiliary Firing)
5 Separator
6 Cyclone Collector
7 Circulating Air Fan
8 Primary Air Fan
9 Rotary Kiln
10 Satellite Coolers (Unax-cooler)

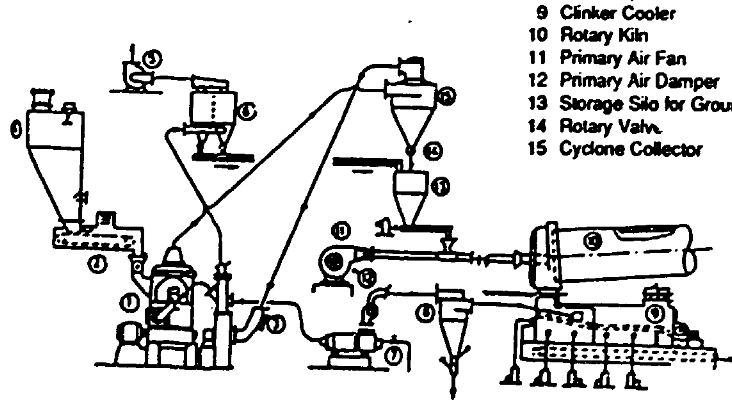
a. Direct Coal Firing Mill



Notation:
1 Raw Coal Silo
2 Weigh Belt Feeder
3 Air-swept Ball Mill (Tirax-mill)
4 Air Heater (Auxiliary Firing)
5 Separator
6 Cyclone Collector
7 Circulating Air Fan
8 Primary Air Fan
9 Rotary Kiln
10 Satellite Coolers (Unax-cooler)
11 Feed Hopper (Working Bin)

b. Semi-direct Coal Firing Mill

Notation:
1 Bowl Mill
2 Weigh Belt Feeder
3 Damper
4 Raw Coal Silo
5 Vent Fan
6 Dust Collector
7 Booster Air Heater
8 Dust Trap
9 Clinker Cooler
10 Rotary Kiln
11 Primary Air Fan
12 Primary Air Damper
13 Storage Silo for Ground Coal
14 Rotary Valve
15 Cyclone Collector



c. In-direct Coal Firing Mill

Figure 23 Coal firing system

3.2.5 Finish grinding mill

Generally, in connection with the cement quality, the initial strength is enhanced by improving the fineness of the product but the long-term strength is not enhanced, so that excessive fine grinding should be avoided even to prevent waste of power.

The Blaine value [cm^2/g] and the residual content [%] on a sieve with 88 (or 90) micron apertures (88 μR) are available as the unit for the degree of the fineness of the product. The Blaine value is used for usual operation management due to its simplicity in measurement. This unit will, however, be insufficient when some improvement is to be made. The Blaine value indicates an increment in the specific surface area of the object to be ground, that is, the amount of energy consumed for grinding, while the 88 μR value represents the residual rough particle content not contributing directly to the strength of the product. Although there is a correlation between these two values for the fineness of the products produced from the same system, an attempt to improve the grinding efficiency means nothing other than an attempt to achieve a lower 88 μR value with a lower Blaine value. JIS, for example, specifies that ordinary portland cement should have a Blaine value of 2500 or more [cm^2/g] but it provides no prescription for 88 μR [%]. When the residue on a 88 μ sieve is too high, there may be some cases where the prescribed value 70 or more [kgf/cm^2] for 3 days, or 150 or more [kgf/cm^2] for 7 days cannot be cleared. In this connection, the international standard for the 88 μR value of cement is within the range of 1 to 2 [%], while that for the Blaine value is within the range of 3,050 - 3,300 [cm^2/g].

The particle size distribution of the product varies substantially depending on the mill types, and the product by the open circuit process has a broad particle size distribution as compared to the product by the closed circuit process. And, when half-burned raw material is mixed in the clinker, an unusually high Blaine value is sometimes obtained because such material is easily ground. In particular, when a number of mills with different sizes and systems are used, to avoid erroneous judgments, it is desirable to control the Blaine value together with 88 μR.

In the closed circuit process, a dynamic separator is provided to avoid excessive grinding of the product and mixing of coarse particles. Though various types of separators have been developed, mechanism to adjust a critical particle diameter by a balance of circulating ascending current and whirling current is common, so that such separators are generically called air separators. Even including the power for the separator and the attached fan, power consumption by the closed circuit process is 10 to 15% less than by the open circuit process. Since each separator is designed so as to allow changing of classification properties, a key point to efficiently operate this system is to control the feed quantity to the mill so as to keep an appropriate circulation rate (generally 200 to 300%) by taking into consideration the grindability of the clinker and the desired fineness of the product.

In case of trying to improve the fineness of the product with the open circuit mill whose length is about three times of its diameter, that is, relatively short, it may be successfully done by installing a separator and changing to the closed circuit process.

A detailed description on the efficiency improvement of the mill itself is provided above in the paragraph on the raw mill. To avoid repetition, no further description is made here. To maintain the optimum medium filling amount is important for any kind of ball mill. It is advisable that once the optimum operation conditions have been determined, the operation sound of the mill shell at that time should be memorized or the noise level and frequency characteristics should be measured when measuring instruments are available. Thereafter, the difference from these in the sound will allow judging whether the operation conditions are appropriate or not. When the operation technique attains this level, an acoustic feed control system using a microphone can be successfully introduced.

Needless to say, operating the mill under an overload condition must be avoided. To reduce the load of the finishing mill intentionally because of its higher sintering capacity compared to the kiln, however, is not recommendable except for such special cases as electric power supply being limited. Usually, it will be more profitable to operate the mill with full load and thereby reduce the operation hours for the day. Especially when power is supplied from the public power supplier, prior negotiation should be made with the supplier side so that operation can be done intensively during the nighttime zone with less power demand. This should bring about mutual merits.

In the finish grinding process, grinding with blast furnace slag blended in the clinker increases electric power unit consumption rate in this process. In some cases, also fuel may be required. However, these increases in the unit consumption rate are by far smaller than the total energy unit consumption required for burning clinkers. Therefore, this will result in larger conservation of the energy unit consumption in terms of value per product cement ton. It should, however, be noted that this will make no sense if it brings about some discount in the product price because of the decline in the product quality. Closest attention should be paid to the quality control of the base clinker and the mixtures.

4. Conclusion

The cement industry in Japan has drastically changed its production process from the wet process to the dry process and promoted the NSP system as increasing production scale. Since energy cost of total cement production cost is large, energy conservation is an important matter in technical improvement activities. The cement production cost depends on the adopted production process. The wet process cannot defeat the dry process as regards energy consumption. At the technical level of quality and productivity, there is no reason why the adoption of the dry process should be impeded. The improvement of a cement plant, however, needs large investment. The timing of the investment of process improvement must be carefully determined taking into consideration the budgetary condition of enterprises and the outlook of the cement market.

Before improving a process, activities of "good housekeeping" and "equipment improvement" should be applied to promote energy conservation.