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UNITED NATIONS

INDUSTRIAL DEVELOPMENT ORGANIZATION

THE FINAL REPORT

ON

PROGRAMME FOR RATIONAL USE OF ENERGY RESOURCES

IN

PULP PAPER AND GLASS INDUSTRY

IN

PHILIPPINES AND THAILAND

UNIDO Contract: 92 161

Project No: US RAS 92 035

The Energy Conservation Center, Jaqan

CONTENTS

1. Preface

The Energy Conservation Center, Japan(ECC) have been contracted UNIDO for the subcontract to execute the project. The services required for the subcontractor composes of two works : (1) Implementation of plant observations in Philippines and Thailand including supervision of the local counterparts and (2) Organization of a seminar and holding lectures as well as taking care for the dissemination of technical manuals in Philippines and Thailand. Both of them have already been completed on schedule in accordance with the Terms of Reference of the subcontract.
The final report describes the results of the all of the duties including the activities and evaluation.

An remarkable increase in energy demand, particularly among South East Asian countries, has been marked in recent years. Growing economy of the Asian countries is fully expected to continue at rapid pace, together with a corresponding increase in energy consumption. Energy Conservation means rational use of energy and requires to promote advancement/industrialization of every country in the world. The international competiting power will become strong by energy conservation promotion because production cost can be reduced.

In addition, the world environmental issue is a subject of the highest importance. The most effective solution of environmental problem is said to promote energy conservation.
UNIDO has been actively engaging in the promotion of program in this field. Joint technical assistance activities of UNIDO and Japan will contribute to the development of economy and human life in Asian countries through this programme. This activity owes much to Industrial Development Division of UNIDO for helpful suggestions and special assistance.
This report is summary of the Program for Rational Use of Energy Resources in pulp/paper and glass industry, the seminar held in February 1993 and the field survey carried out in Sptember 1992 both in Philippines and Thailand.

2. Outline of the programme

This programme is to prepare the handy manual for rational use of energy source in pulp/paper and glass industry to the industrial developing countries.
The activities in the programme are as follows:

July 1992:

- Assignment of 2 experts in pulp/paper and glass industry in Japan

September 1992:

- Field survey in pulp/paper and glass industries in Philippines and Thailand by the experts

September 1992 to January 1993:

- Preparation of seminar textbook in pulp/paper and glass industry by the experts in Japan

February 1993:

- Holding of seminars for dissemination of rational use of energy source in pulp/paper and glass industry in Philippines and Thailand with the seminar textbook

February to March 1993:

- Preparation of the draft handy manuals in pulp/paper and glass industry by the experts in Japan

March 1993:

- Submitting of 3 copies of the draft handy manuals in pulp/paper and glass to UNIDO

December 1993:

- Submitting of 600 copies of the handy manuals in pulp/paper and glass to UNIDO

3. Evaluation of the seminar

This study attempts to evaluate the seminar on the programme for rational use of energy resources in pulp/paper and glass industry in Philippines and Thailand held by United Nations Industrial Development Organization(UNIDO) and Ministry of International Trade and Industry(MITI), Japan, organized by The Energy Conservation Center, Japan and hosted by Department of Energy, Philippines and Ministry of Science, Technology and Environment, Thailand on 18th, 19th February in Bangkok at Asia Hotel and on 23rd, 24th February in Manila at Garden Hall of Hotel Nikko Manila in 1993. 70–90 participants from government agencies, mostly factories attended the seminar.

In Philippines, 64% of Energy demand is currently covered by oil. Aming to reduce dependency on imported oil, the government has been promoting development of domestic energy resources, diversification of energy supply sources and improvement of energy use efficiency. In 1979, production of domestic crude oil started. Production of coal and hydropower has increased gradually. Geothermal energy has been developed with great success and in terms of capacity of geothermal power plant.

In Thailand, main goal of energy policy consist of the conservation of oil, development of domestic resources, introduction of natural gas, domestic supply of fuel for electricity generation. Domestic gas and oil fields have been developed after the oil crisis. Share of oil has declined and from 90% in 1975 to 71% in 1990. On the other hand those of coal and natural gas has increased. for the last few years primary energy demand had a high growth rate with high economic growth.

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 60–70 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 pulp/paper and glass industry using textbooks (preliminary draft handy manuals) based on the results of the factory survey in Philippines and Thailand. The seminar was covered with general energy conservation ideas in both pulp/paper and glass industries. Responses of participants were very favorable and seminar could be considered to have been very successful.

There are six 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 Philippines and Thailand 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 pulp/paper and glass industry, 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 those 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

February	16	1993	Narita(10:30) to Bangkok(15:25)TG641
	17		Preparation of the seminar
	18		Seminar, Pulp/paper Industry
	19		Seminar, Glass Industry
	20		Off day(Saturday)
	21		Bangkok(10:40) to Manila(14:45)TG620
	22		Preparation of the seminar
	23		Seminar, Pulp/paper Industry
	24		Seminar, Glass Industry
	25		Manila(14:40) to Narita(19:30)JAL742

1) Seminar program in Thailand

23 February 1993, at Asia Hotel, Bangkok

Seminar on Energy Conservation in Pulp/paper Industry

9:00–9:30	Registration
9:30–9:40	Address by Ms. Magdarena F. Savarain Chief, Appropriate Technologies Unit, UNIDO
9:40–9:50	Address by Mr. Norio Fukushima General Manager, International Cooperation Department, The Energy Conservation Center(ECC), Japan
9:50–10:00	Address by Dr. Sangpong Chantavorapap Deputy Director General, Department of Energy Development and Promotion(DEDP), Ministry of Science, Technologies and Environment, Thailand
10:00–10:30	Coffee break
10:30–12:00	Energy Conservation in Pulp/paper Industry(1)
12:00–13:30	Lunch
13:30–14:30	Energy Conservation in Pulp/paper Industry(2)
14:30–15:00	Coffee break
15:00–16:00	Questions and Answers
17:30	Closing

19 February 1993, at Asia Hotel, Bangkok

Seminar on Energy Conservation in Glass Industry

9:00–9:30	Registration
9:30–12:00	Energy Conservation in Glass Industry
12:00–12:30	Question and Answer
12:30–14:00	Lunch
14:00–16:00	Demonstration of Factory Energy Audit(1)
16:00–16:30	Coffee break
16:30–17:30	Demonstration of Factory Energy Audit(2)
17:30	Closing

Picture on seminar (1)

Picture on seminar (2)

Seminar in Thailand

2) Seminar program in Philippines

23 February 1993, at Garden Hall of Hotel Nikko Manila, Manila

Seminar on Energy Conservation in Pulp/paper Industry

9:00–9:30	Registration
9:30–10:00	Address by Ms. Griselda G. J. Bausa Officer-in-Charge, Energy Operation, Department of Energy(DOE), Philippines
9:40–9:45	Address by Mr. Kevin McGrath UNDP/UNIDO Resident Representative UNDP
9:45–9:50	Address by Ms. Magdarena F. Savarain Chief, Appropriate Technologies Unit, UNIDO
9:50–9:55	Address by Mr. Noritaka Ehara Director, Manila Center, Japan External Trade Organization(JETRO), Japan
9:55–10:00	Address by Mr. Rufino B. Bomasang Officer-in-Charge, Office of the Undersecretary, Department of Energy(DOE), Philippines
10:00–10:10	Presentation of Plagues of Appreciation: by Hon. Delfin L. Lazaro Secretary Department of Energy(DOE), Philippines
10:10–10:30	Coffee break
10:30–12:00	Energy Conservation in Pulp/paper Industry(1)
12:00–13:30	Lunch
13:30–14:30	Energy Conservation in Pulp/paper Industry(2)
14:30–15:00	Coffee Break
15:00–16:00	Questions and Answers
16:00	Closing

24 February 1993, at Garden Hall of Hotel Nikko Manila, Manila

Seminar on Energy Conservation in Glass Industry

9:00–9:30	Registration
10:00–12:00	Energy Conservation in Glass Industry
12:00–12:30	Question and Answer
12:30–14:00	Lunch
14:00–16:00	Demonstration of Factory Energy Audit(1)
16:00–16:30	Coffee break
16:30–17:30	Demonstration of Factory Energy Audit(2)
17:30	Closing

Picture on seminar (1)

Picture on seminar (2)

Seminar in Philippines

5. **Schedule of the factory survey**

September	6	1992	Narita(12:55) to Bangkok(17:10) JL717
	7		Department of Energy Development & Promotion, UNIDO Bangkok Office, JETRO Bangkok Center, Energy Conservation Center of Thailand,
	8		Siam Plate Glass Industry LTD (glass)
	9		Thai Development Paper LTD (paper)
	10		Thai glass industries LTD (glass)
	11		Thai UNion Paper LTD (paper)
	12		Saturday
	13		Sunday
	14		Card Board Co. LTD (paper)
	15		Bangkok(10:30) to Manila(14:35) TG620
	16		Office of Energy Affairs, JETRO Manila Center, UNIDO Manila Office, Embassy of Japan in Manila
	17		Premium Packaging International, INC. (paper)
	18		Union Glass and Container Corporation (glass)
	19		Saturday
	20		Sunday
	21		Aclem Paper Mill,INC. (paper)
	22		Kimberly-Clark (paper)
	23		Massive Paper Mills (paper)
	24		Manila(14:20) to Narita(19:15) PR432

6. Japancse experts list

1)Field survey

1. Mr. Yukio Nozaki
   Technical Adviser
   The Energy Conservation Center, Japan
2. Mr. Akira Koizumi
   Technical Adviser (Paper expert)
   The Energy Conservation Center, Japan
3. Mr. Keiichi Mukai
   Technical Adviser (Glass expert)
   The Energy Conservation Center, Japan

2)Seminar

1. Mr. Akira Koizumi
   Technical Adviser (Paper expert)
   The Energy Conservation Center, Japan
2. Mr. Keiichi Mukai
   Technical Adviser (Glass expert)
   The Energy Conservation Center, Japan

3)Home office

1. Mr. Norio Fukushima
   Project Leader
   The Energy Conservation Center, Japan
2. Mr. Akira Koizumi
   Technical Adviser (Paper expert)
   The Energy Conservation Center, Japan
3. Mr. Keiichi Mukai
   Technical Adviser (Glass expert)
   The Energy Conservation Center, Japan

7. Counterparts list

1)Thailand

Mr. Amorn Phandhu-Fung
Director
Energy Economics Division
Department of Energy Affairs
Kasatsuk Bridge
Bangkok 10330
Thailand
Tel 223-0021

2)Philippines

Mr.Rufino B. Bomasang
Executive Director,
Office of Energy affairs
Office of The President
PNPC Complex, Merrit Road
Fort Bonifacio
Metro Manila
Philippines
Tel 817-8603

Appendix 1. List of the surveyed factories

Appendix 1. List of the surveyed factories

Thailand

1)Pulp/paper(three factories)

1. Thai Development Paper LTD
14 Tathery Rd.
P.O. Box 27-100,
Samuthprekarn 10280
Tel. 395-0665

2.Thai Union Paper LTD
131 Poochaosamingprai Rd.
Phrapradeeng,
Samuthprekarn 10130
Tel. 394-0622

3.Card Board Co. LTD
106 Pabolyotin Rd. 42
Bangkhen,
Bangkok 10900
Tel. 579-5646

2)Glass(two factories)

4. Siam Plate Glass Industry LTD
83 Moo 5 Takaan,
Bangpakong District,
Chachoensao
Tel. 212-4680

5. Thai Glass Industries LTD
15 Raiburana Road,
P.O Box 720, Bangkok 10501
Tel. 427-0060

Philippines

1)Pulp/paper(three factories)

1. Premium Packaging International Inc.
   (A subsidiary of San Miguel Corporation)
   SMPP Center, 109 C.Palanca St.
   Legaspi Village, Makati,
   Metro Manila
   Tel. 949-8000
2. Aclem Paper Mills,Inc
   501 Juan Luna St.
   P.O. Box 2080
   Manila
   Tel. 846-0011
3. Massive Paper Mills
   93 B.Delfin Street
   Marulas, Valenzuela,
   Bulacan
   Tel. 361-2724

2)Glass(two factories)

4. Union Glass and Container Corporation
   D.Rodriguez, JB, Avenue
   Ugong, Pasic,
   Metro Manila,
   Tel. 873-1170
5. Kimberly-Clark Philippines Inc.
   United San Pedro Sutid
   4023 San Pedro,
   Laguna
   Tel. 846-0031

Appendix 2. Participants list of the seminar

Appendix 2. Participants list of the seminar

Thailand : 18 February 1993 (Pulp/paper)

1.	Mr. Worraphat Poonsiri	Teppatana Paper Mill Company
2.	Mr. Veeraphan Sattayawinu	Capital Paper Manugacturers Co. Ltd.
3.	Mr. Preecha Phomkad	Capital Paper Manugacturers Co. Ltd.
4.	Mr. Sutas Sookniyom	Cellox Paper Company Ltd.
5.	Mr. Manoch Sangtawan	Cellox Paper Company Ltd.
6.	Mr. Veerapol Sithiwang	Kimberly Clark (Thailand) Ltd.
7.	Mr. sudarat Thawornkit	Petchkasem Craft Co. ltd.
8.	Mr. Apichart posu	Thai Development Paper Co. Ltd.
9.	Mr. Pornpisit War vitaya	Thanatan Paper Co. Ltd.
10.	Mr. Chaichan Chareonsuk	Thai Paper Co. Ltd.
11.	Mr. Danai Pattamasuntiwong	Siam Pulp & Paper Co. Ltd.
12.	Mr. Surajit Tanwatana	Thai Paper Co. ltd.
13.	Mr. Busayant Boon-Long	Siam Craft Industry Co. Ltd.
14.	Mr. chuan Yipyintum	Thanatarn paper co. Ltd.
15.	Mr. Sompho Homjumroon	Teppatana Paper Mill Co. ltd.
16.	Mr. Worraphat Poonsiri	Teppatana Paper Mill Co. Ltd.
17.	Mr. Manit Subhaput	Bang Pa-In Paper Mill Co. Ltd.
18.	Mr. Prateep Jungmuphanbon	Sahathai Paper Co. ltd.
19.	Mr. Dusit Sitthivech	Siam Pulp & Paper Co. Ltd.
20.	Mr. Wichiian Youyongwatana	Thai Paper Co. Ltd.
21.	Mr. Wirat Sricharoen	Thai-Scotts Co. ltd.
22.	Mr. P[illegible] Wongvisuttirat	Thai Development Paper Co. Ltd.
23.	Mr. Jroon Tochort	Sahagroup Co. Ltd.
24.	Mr. Jumnain Konthem	Nakornlung Paper Co. Ltd.
25.	Mr. Boonchob Pumrin	Microfiber Industry Co. Ltd.
26.	Mr. Apichart Paopuak	Microfiber Industry Co. Ltd.
27.	Mr. Preecha Jowtragoon	Bangkok Float Glass Co. Ltd.
28.	Mr. Charesak Chuaypeng	Thai Glass Industries Co. Ltd.
29.	Mr. Chusak Thongsari	Bangkok Glass Industrial Co. Ltd.
30.	Mr. Ponya Koogok	Luckcy Glass
31.	Mr. Li shou Han	Luckcy Glass
32.	Mr. Chatpong Luengjuthakorn	Thai-Asahi Glass Co. Ltd.
33.	Mr. Somsak Chanudoinphorn	Luckcy Glass
34.	Mr. Komon Lomchantrasilp	Thai-Asahi Glass Co. Ltd.
35.	Mr. Vinij Panpanich	The Eastern Industrial Co. Ltd.

36.	Mr. Banjong Prasertchareonsuk	The Eastern Industrial Co. Ltd.
37.	Mr. Pittaya Kruekhuenpet	Energy Conservation Center Division
38.	Mr. Tipakorn Poolsawad	National Energy Policy Office
39.	Mr. Chatri Tanakitiviroon	Provincial Electric Authority
40.	Mr. Thumasak Suwanatep	Department of Energy Development and Promotion(DEDP)
41.	Mr. Wasant Tanya	Energy Training Center
42.	Mr. Redee Pirivapongpan	Manager Daily newspaper
43.	Mr. Wiraphon Bharsapraharce	DEDP
44.	Mr. Tasaporn Ponedee	Provincial Electric Authority
45.	Mr. Phichai Chantalap	Provincial Electric Authority
46.	Mr. Sunchai Saranak	Energy Trainnig Center
47.	Mr. Boonthong Ungtrakul	DEDP
48.	Mr. Akprapan Aksornpan	National Energy Policy Office
49.	Mr. Vinai Chinarong	Energy Trainnig Center
50.	Mr. Virat Songngam	DEDP
51.	Mr. Somkiat Sutiratana	DEDP
52.	Mr. Thongdee Benjamongkong	Energy Conservation Center
53.	Mr. Bancherd Kajchamaporn	The Energy Conservation Center of Thailand
54.	Mr. Butrat Butprom	The Manager Co. Ltd.

Thailand : 19 February 1993 (Glass)

1.	Mr. Preecha Srisailoan	Microfiber Industry Co. Ltd.
2.	Mr. Opas Ritsmitchai	Microfiber Industry Co. Ltd.
3.	Mr. Lerdchai Thanyawattana	General Glass Co. Ltd.
4.	Mr. Boonchob Pumrin	Microfiber Industry Co. Ltd.
5.	Mr. Apichart Paopuak	Microfiber Industry Co. Ltd.
6.	Mr. Preecha Jowtragoon	Bangkok Float Glass Co. Ltd.
7.	Mr. Charesak Chuaypeng	Thai Glass Industries Co. Ltd.
8.	Mr. Chusak Thongsari	Bangkok Glass Industrial Co. Ltd.
9.	Mr. Ponya Koogok	Luckcy Glass
10.	Mr. Li shou Han	Luckcy Glass
11.	Mr. Chatpong Luengjuthakorn	Thai-Asahi Glass Co. Ltd.
12.	Mr. Somsak Chanudomphorn	Luckcy Glass
13.	Mr. Komon Lomchantrasilp	Thai-Asahi Glass Co. Ltd.
14.	Mr. Mongkol Techachongcharoen	Bangkok Float Glass Co. Ltd.
15.	Mr. Komvit Thiemvej	Bangkok Float Glass Co. Ltd.
16.	Mr. Paitoon Sermsirimongkol	Panjapol Fibre Container Co. Ltd.
17.	Mr. Tanid Bhasathiti	Thai-Asahi Glass Co. Ltd.
18.	Mr. Katavut Lertkiatrachatah	Thai-Asahi Glass Co. Ltd.
19.	Mr. Wittaya Siriprasertsook	Hiang Seng Fibre Container Co. Ltd.
20.	Mr. Komson Worapattrakul	Siam Glass Industry co. Ltd.
21.	Mr. Todsaphol Khuntakeereewatt	Microfiber Industries Co. ltd.
22.	Mr. Somchai Keawngam	General Glass Co. ltd.
23.	Mr. Suradech L. Pongchai	Ocean Glass Co. Ltd.
24.	Mr. Sombud Summar	Glass Organization Co. Ltd.
25.	Mr. Cha-Oom Panmogkol	Glass Organization Co. Ltd.
26.	Ms. Apina Chokpuntaree	Metropolitan Glass Factory
27.	Ms. Suwanna Tantiprasitthikul	Ocean Glass Co. ltd.
28.	Mr. Choopong Karunamit	Ocean Glass Co. ltd.
29.	Mr. Kasem Sotthiwat	Microfiber Industry Co. Ltd.
30.	Mr. Naris Krajladsiri	Bangkok Glass Industry co. Ltd.
31.	Mr. Manoch Sangtawan	Cellox Paper Company Ltd.
32.	Mr. Veerapol Sithiwang	Kimberly Clark (Thailand) Ltd.
33.	Mr. sudarat Thawornkit	Petchkasem Craft Co. ltd.
34.	Mr. Apichart posu	Thai Development Paper Co. Ltd.
35.	Mr. Pornpisit Waravitaya	Thanatan Paper Co. Ltd.
36.	Mr. Chaichan Chareonsuk	Thai Paper Co. Ltd.
37.	Mr. Danai Pattamasuntiwong	Siam Pulp & Paper Co. Ltd.

38.	Mr. Surajit Tanwatana	Thai Paper Co. ltd.
39.	Mr. Busayarit Boon-Long	Siam Craft Industry Co. Ltd.
40.	Mr. chuan Yipyintum	Thanatam paper co. Ltd.
41.	Mr. Sompho Homjumroon	Teppatana Paper Mill Co. ltd.
42.	Ms. Vilun Patana	Thai Sin Enterprise Co. ltd.
43.	Ms. Jirawan Bunsin	Thai Sin Enterprise Co. ltd.
44.	Mr. Pittaya Kruekhuenpet	Energy Conservation Center Division
45.	Mr. Tipakorn Poolsawad	National Energy Policy Office
46.	Mr. Chatri Tanakitiviroon	Provincial Electric Authority
47.	Mr. Thumasak Suwanatep	Department of Energy Development and Promotion(DEDP)
48.	Mr. Wasant Tanya	Energy Training Center
49.	Mr. Wiraphon Bharsapraharce	DEDP
50.	Mr. Tasaporn Ponedee	Provincial Electric Authority
51.	Mr. Phichai Chantalap	Provincial Electric Authority
52.	Mr. Sunchai Saranak	Energy Training Center
53.	Mr. Boonthong Ungtrakul	DEDP
54.	Mr. Vinai Chinarong	Energy Training Center
55.	Mr. Virat Songngam	DEDP
56.	Mr. Somkiat Sutiratana	DEDP
57.	Mr. Thongdee Benjamongkong	Energy Conservation Center
58.	Mr. Bancherd Kajchamaporn	The Energy Conservation Center of Thailand

Philippines 23 February 1993 (Pulp/paper)

1.	Mr. Roger Arato	Kimberly Clark Phils. Inc.
2.	Mr. Alfredo S. Cabrera	Paper Industries Corp. of the Phils.
3.	Mr. Carlos Cheng	Fedco Paper Corporation
4.	Mr. Anthony Chiongson	Liberty Paper
5.	Mr. Alexander Dabuet	Worldwide Paper Mill Inc.
6.	Mr. Salvador Dasigao	Manila Paper Mills Inc.
7.	Mr. Jose P. Duarte	W & L Corporation
8.	Mr. Victor G. Jr. Esguerra	Newtech Pulp Inc.
9.	Mr. Emmanuel V. Gaspar	Trust International Paper Company
10.	Mr. Dionisio Go	Vanson Paper Industrial Corp.
11.	Mr. Nemesio Francieco Liwanag	Liberty Paper Inc.
12.	Mr. Sol Magsipoc	United Pulp and Paper Co. Inc.
13.	Mr. Pascual C. Mendoza	Manila Paper Mills Inc.
14.	Mr. Domingo D. Ongoco	Bataan Pulp and Paper Mills
15.	Mr. Dewin Q. Pacia	Kimberly Clark Phils. Inc.
16.	Mr. Mario S. Pan	Trust International Paper Co.
17.	Mr. Abel C. Sabularse	Republic-Asahi Glass Corp.
18.	Mr. Rogelio C. Sapmiento	Worldwide Paper Mills Inc.
19.	Mr. Danilo C. Yabao	San Miguel Packaging Products
20.	Mr. Jose L. Jr. Zulueta	Mayleen Paper Inc.
21.	Mr. Rcdrigo M. Calaguas	Manila Electric Company
22.	Mr. Mario R. Carlos	Energy Utilization Dept., PNOC-ERDD
23.	Mr. Donate de la Cruz	Univ. of the Phils.
24.	Mr. Alberto Dalusung	Energy Development & Utilization Foundation Inc.
25.	Mr. Virgilio B. Fule	JF Steam System Controls & Eng'g.
26.	Mr. Greg Gonzales	PAEE/PECCI, ENMAP
27.	Mr. Ramo A. Loyola	San Miguel Corporation
28.	Mr. Jorge H. Lucas	National Power Corporation
29.	Mr. Glemm Mirandilla	PCIERD
30.	Mr. Renato Olegario	PCIERD
31.	Mr. Leonardo G. Osilla	National Power Corporation
32.	Mr. Alberto L. Pacoua	PCIERD, DOST
33.	Mr. Marcial P. Semira Jr.	Donewell Consultants
34.	Ms. Rizalinda de Leon	Univ. of the Phils.
35.	Mr. Rodrigo Tadeo Y. Nocete	Cebu Chamber of Commerce & Industry
36.	Mr. Joselito Palacio	Cebu Chamber of Commerce & Industry

37.	Mr. Nonilo A. Pena	PCIERD/DOST
38.	Mr. Hendrik Gommer	UNDP
39.	Mr. Albrecht Kaupp	UNDP Project
40.	Mr. Vicente Fabro	Hachi International
41	Mr. Griselda G. J. Bausa	Department of Energy
42.	Ms. Tina Anec	Manila Times
43.	Ms. Estela de la Paz	Business World
44.	Mr. Kathi Espina	Manila Chronicle
45.	Mr. Leo Walet	
46.	Mr. Charlie A. Quirante	Department of Energy
47.	Mr. Peal Martin T. Ruiz	Department of Energy
48.	Mr. Marco O. Bawagan	Department of Energy
49.	Mr. Remon Gagarin de Jesus	Department of Energy
50.	Mr. Roaalie Joan Sotelo	Department of Energy
51.	Ms. Helen B. Arias	Department of Energy
52.	Mr. Felix Regacho	Department of Energy
53	Ms. Rose Sumulong	Department of Energy
54.	Ms. Edna Morales	Department of Energy
55.	Ms. Tess Jaurigue	Department of Energy
56.	Ms. Imelda Sarenas	Department of Energy
57.	Ms. Suaana Arccena	Department of Energy
58.	Mr. Jovito Marian	Department of Energy
59.	Mr. Delgin Gu[illegible]	Department of Energy

Philippines 24 February 1993 (Glass)

1.	Mr. Roberto G. Agustin	Republic-Asahi Glass Corp.
2.	Mr. Emmanuel Alcantara	San Miguel Yamamura Asia Corporation
3.	Mr. Rodulfo Alfafara	National Power Corporation
4.	Mr. Delano O. Catli	Republic Asahi Glass Corp.
5.	Mr. Norberto L. del Rosario	San Miguel Yamamura Asia Corporation
6.	Mr. Felizardo C. Fajardo	SMC - Manila Glass Plant
7.	Mr. Wilfredo S. Gabriel	ACI Phils. Inc.
8.	Mr. Rainer N. Gamboa	AGS Enterprises
9.	Mr. Felipe Gaarcia	National Power Corp.
10.	Mr. Rene V. Guarin	National Power Corp.
11.	Mr. Alberto Hidalgo	SMC - Mandaue Glass Plant
12.	Mr. Rodolfo S. Judico	National Power Corp.
13.	Mr. Vince R. Ladaw	A. Dimaguila Ent. Inc.
14.	Mr. Allan S. Lardizabal	San Miguel Yamamura Asia Corporation
15.	Mr. Ronaldo S. Libunao	San Miguel Yamamura Asia Corporation
16.	Mr. Manuel Maixi	San Miguel Yamamura Asia Corporation
17.	Mr. Bejamin C. Mawili	Pacific Glass Products Mfg. Corp.
18.	Mr. Segundo Ortiz	ACI Phils. Inc.
19.	Mr. Riki J. Padilla	National Power Corporation
20.	Mr. Fidel V. Ricafrente	Premium Packaging Int'l. Inc.
21.	Mr. Alfredo G. Roderiguez Jr.	SMC - Manila Glass Plant
22.	Mr. Abel C. Sabularse	Republic-Asahi Glass Corp.
23.	Mr. Rolando C. Salbador	GNA Glass Corp.
24.	Mr. Eduardo Solayao	National Power Corporation
25.	Mr. Edmundo Solon	Visayan Glass
26.	Mr. Aldrin Neilson UY	San Miguel Yamamura Asia Corporation
27.	Mr. Manuel UY	National Power Corp.
28.	Mr. Danilo C. Yabao	San Miguel Packaging Products
29.	Mr. Augusto Yulo Jr.	Unicon Safety Glass Inc.
30.	Mr. Honorio V. Factora	Kimberly Clark Phils. Inc.
31.	Mr. Alfredo S. Cabrera	Paper Industrial Corp.
32.	Mr. Alexander Dabueet	Worldwide Paper
33.	Mr. Sol Magsipoc	United Pulp and Paper
34.	Mr. Vic Esguerra	Newtech Phils. Inc.
35.	Mr. Rodrigo M. Calaguas	Manila Electric Company
36.	Mr. Mario R. Carlos	Energy Utilization Dept., PNOC-ERDD
37.	Mr. Donate de la Cruz	Univ. of the Phils.

38.	Mr. Alberto Dalusung	Energy Development & Utilization Foundation Inc.
39.	Mr. Virgilio B. Fule	JF Steam System Controls & Eng'g.
40.	Mr. Greg Gonzales	PAEE/PECCI, ENMAP
41.	Mr. Ramo A. Loyola	San Miguel Corporation
42.	Mr. Jorge H. Lucas	National Power Corporation
43.	Mr. Glemm Mirandilla	PCIERD
44.	Mr. Renato Olegario	PCIERD
45.	Mr. Leonardo G. Osilla	National Power Corporation
46.	Mr. Alberto L. Pacoua	PCIERD, DOST
47.	Mr. Marcial P. Semira Jr.	Donewell Consultants
48.	Ms. Rizalinda de Leon	Univ. of the Phils.
49.	Mr. Rodrigo Tadeo Y. Nocete	Cebu Chamber of Commerce & Industry
50.	Mr. Joselito Palacio	Cebu Chamber of Commerce & Industry
51.	Mr. Nonilo A. Pena	PCIERD/DOST
52.	Mr. Hendrik Gommer	UNDP
53.	Mr. Albrecht Kaupp	UNDP Project
54.	Mr. Vicente Fabro	Hachi International
55.	Mr. Griselda G. J. Bausa	Department of Energy
56.	Ms. Tina Anec	Manila Times
57.	Ms. Estela de la Paz	Business World
58.	Mr. Kathi Espina	Manila Chronicle
59.	Mr. Leo Walet	
60.	Mr. Charlie A. Quirante	Department of Energy
61.	Mr. Peal Martin T. Ruiz	Department of Energy
62.	Mr. Marco O. Bawagan	Department of Energy
63.	Mr. Remon Gagarin de Jesus	Department of Energy
64.	Mr. Roaalie Joan Sotelo	Department of Energy
65.	Ms. Helen B. Arias	Department of Energy
66.	Mr. Felix Regacho	Department of Energy
67.	Ms. Rose Sumulong	Department of Energy
68.	Ms. Edna Morales	Department of Energy
69.	Ms. Tess Jaurigue	Department of Energy
70.	Ms. Imelda Sarenas	Department of Energy
71.	Ms. Suaana Arccena	Department of Energy
72.	Mr. Jovito Marian	Department of Energy
73.	Mr. Delgin Guse	Department of Energy

Appendix 3. Terms of Reference

Appendix 3. Terms of Reference

28/04/92

RATIONAL USE OF ENERGY RESOURCES IN GLASS AND PAPER INDUSTRY

TERMS OF REFERENCE FOR SUBCONTRACTING ORGANIZATION

I. Project objective

To increase the awareness and knowledge of government officials and industrial users on energy saving technologies in the Pulp and Paper and Glass Industry in the Philippines and Thailand.

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 energy conservation/savings 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, 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 mechanics 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 co-operation projects.

UNIDO has already implemented many projects in the field of energy management in different countries and, under UNDP project DP/PHI/82/002 "Industrial Energy Management Consultancy and Training" - Phase I and Phase II and project DP/PHI/87/007, which is under implementation, UNIDO has assisted the Philippines to increase the capacity/capabilities of the Energy Management and Consultancy Service (EMCS), in the establishment of a Fuel and Appliance Testing Laboratories, and an Energy Certification Programme.

Last year, a project - US/RAS/90/075 "Programme for Rational Use of Energy in the Iron and Steel and Textile Industry" - was approved. Surveys, seminars and demonstration on factory audits on the application of adequate technologies in the rational use of energy, were conducted by Japanese and UNIDO specialists in Malaysia and Indonesia. As a result of this programme, a Manual on Energy Saving Technologies for Iron and Steel and Textile Industries has been prepared. The Manuals, currently available in English, will be translated 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 has prompted UNIDO to carry out a similar programme this year.

In the proposed project, activities will be undertaken in the Pulp and Paper and Glass industry in the Philippines and Thailand, where many of the above mentioned industries are to be found, and human resources as well as technological levels are adequate for introducing energy conservation technologies. Also, strong counterpart institutions are available.

The experience obtained through this project will be applied to other programmes/projects which involve more countries (regions) through the publications of the manuals in the energy saving technologies.

Under this regional programme, the Philippines and Thailand as well as other developing countries will benefit at the end of the project UNIDO's experience in promoting and applying energy saving technologies in the pulp and paper and glass industry, 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 field surveys at plant level in Philippines and Thailand in glass and paper industry in order to define the various factors of excessive energy consumption and inefficient energy utilization. With support of government and local counterparts in both countries at a few plants among the above mentioned industries should be selected, which are presently energy intensive and could expect considerable improvements on their energy consumption. The results of these observations will be utilized for the preparation of the draft manual and demonstrated during the implementation of seminars.

B. In close co-operation with the Philippine Office of Energy Affairs and the Ministry of Science, Technology and Energy of Thailand, seminars will be held for top executives, middle class 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 as well as other asian 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 Philippines and Thailand as well as from UNIDO HQ.

C. UNIDO expects that the subcontractor prepares 600 copies of the manual in English on energy conservation/saving technologies in glass and 600 copies in English of the manual on energy conservation/saving technologies in paper industries.

The two manuals will describe the selected energy conservation subjects according to the following frameworks:

Manual 1 - Glass

- Character of Manual
- Characteristics of Energy Consumption
  - Manufacturing Process and Main Facilities
  - Situation of Energy Consumption
  - Melting tank
  - Working hearth
  - Fore hearth
  - Lehr
- Rational Use of Energy
  - Waste heat recovery
  - Improved insulation and sealing for hearth, lehrs and melting tank

Manual 2 - Paper

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

The manuals will demonstrate innovative energy conservation/saving technologies developed in Japan and adapted to the conditions and requirements of the glass and paper 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 manuals information available on UNIDO's expertise and experience in promoting energy conservation/saving technologies in developing countries as well as available in Japan will be reviewed by the subcontractor and incorporated into the proposed technical manuals.

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

D. A final report which summarizes all work done including the outputs of the seminars held in Thailand and Philippines 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.

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

- 3 experts to implement plant observations in Thailand and Philippines including supervision of the local counterparts

- 2 experts to organize seminars and held lectures as well as take care for the dissemination of the technical manuals in Thailand and Philippines

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.

F. The subcontracting organization will be fully responsible for the provision of all necessary facilities and services to conduct the scheduled seminars in Thailand and Philippines for 2 days and for about 50 participants of each (steel/textile industry) seminar.

In particular the following facilities will be provided by the subcontractor in co-operation with local counterparts in Thailand/Philippines.

- Seminar rooms with sitting accommodations for 50 participants

- Seminar registration desks and receptions

- Interpretation services (English, Japanese and national language)

- Microphones

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

- Podium for lectures

- Miscellaneous services

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.

Appendix 4. Seminar pamphlet

Please return this card to :
Energy Training Center
Energy Economics Division
Department of Energy Development and Promotion

Address
Bangkruai

NONTHABURI

THAILAND 11130

Tel 4240965−6

Lecturer profile

Mr. Akira KOIZUMI (Paper expert)
Technical Advisor
The Energy Conservation Center, Japan

Mr. Keiiti MUKAI (Glass expert)
Technical Advisor
The Energy Conservation Center, Japan

Seminar
on
Energy Conservation
in
Paper and Glass Industry

18−19 February 1993
Seminar Place

Asia Hotel

Sponsored by
United Nations
Industrial Development Organization
(UNIDO)
and
Ministry of
International Trade and Industry, Japan
(MITI)
Organized by
The Energy Conservation Center, Japan
Cooperated by
Department of Energy Development
and Promotion
Ministry of
Science, Technology and Enviroment
Thailand

Appendix 4. Seminar pamphlet

Introduction

Energy conservation means rational use of energy and is required to promote advancement/industrialization in every country in the world. The international trade competition power will become strong by energy conservation promotion because production cost can be reduce by promotion of energy conservation.

In addition, the world environmental issue such as global warming by carbon dioxide and forest destroys by acid rain have now come to receive attention. The energy conservation promotion is recognized as being effective in maintaining good environment conditions. Main energy resources in the world are fossil resources in the world are limited. When industrialization in the world will be advanced, energy issues will occur due to increase energy consumption. One of the important items to solve energy issues is the promotion of energy conservation.

UNIDO has been actively engaged in the promotion of programs in the pertinent field. Joint technical assistance activities of UNIDO and Japan will contribute to the development of economy and human life in Thailand through this seminar.

Seminar Objective

This seminar will be held for the purpose of promotion of the energy conservation technologies in Paper and Glass industry by handy manuals.

Program

1st day Thursday, 18 February 1993

9:00–9:30	Registration
9:30–10:00	Adress by UNIDO, Japan and Thailand side
10:00–10:30	Coffee break
10:30–12:00	Energy Conservation in Paper Industry (1)
12:00–13:30	Lunch
13:30–14:30	Energy Conservation in Paper Industry (2)
14:30–15:00	Coffee break
15:00–16:00	Question and Answer

2nd day Friday, 19 February 1993

9:00–9:30	Registration
9:30–12:30	Energy Conservation in Glass Industry and Question & Answer
12:30–14:00	Lunch
14:00–17:30	Demonstration of Factory Energy Audit (16:00–16:30 Coffee break)
17:30	Closing

Registration Card

Please return this card by 10 February
(Please write in block letter)

Name:

Job Title/Position:

Organization:

Office Address:

Office Telephone:

For inquired on this seminar, please contact :
Energy Training Center
Bangkruai, NONTHARBURI

Tel : 4240965–66
Fax : 4240967

Lecturer profile

Mr. Akira KOIZUMI (Paper expert)
Technical Advisor
The Energy Conservation Center, Japan

Mr. Keiichi MUKAI (Glass expert)
Technical Advisor
The Energy Conservation Center, Japan

UNIDO

Seminar on Energy Conservation in Paper and Glass Industry

23–24 February 1993

Garden Hall
Ground Floor, Hotel Nikko Manila

Sponsored by
United Nations Industrial Development Organization (UNIDO)
and
Ministry of International Trade and Industry (MITI, Japan)

Organized by
The Energy Conservation Center (ECC, Japan)

In Cooperation with the
Department of Energy (DOE, Philippines)

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. And as the international trade competition power becomes stronger, 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 world wide attention. To mitigate these adverse environmental effects, energy conservation promotion must be strongly pursued. An industrialization continue 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 energy conservation programs in developing countries.

This Seminar on Energy Conservation in Paper and Glass Industries is one such activity which UNIDO and ECC, Japan organized in cooperation with the Department of Energy, Philippines to contribute to the development of the nation's human resources and economy.

Seminar Objective

To promote energy conservation and to accelerate technology transfer to paper and glass industries through lecture discussion supplement with reference manuals.

PROGRAM

First Day

Tuesday, 23 February 1993

9:00–9:30	Registration
9:30–10:00	Opening Ceremonies
10:00–10:30	COFFEE BREAK
10:30–12:00	Energy Conservation in Paper Industry
12:00–13:30	LUNCH
13:30–14:30	Energy Conservation in Paper Industry (Continuation)
14:30–15:00	COFFEE BREAK
15:00–16:00	Questions and Answer

Second Day

Wednesday, 24 February 1993

9:00–9:30	Registration
9:30–10:30	Energy Conservation in Glass Industry
10:30–11:00	COFFEE BREAK
11:00–12:00	Energy Conservation in Glass Industry (Continuation)
12:00–12:30	Questions and Answer
12:30–13:30	LUNCH
13:30–14:00	Registration
14:00–16:00	Energy Audit Equipment Demonstration
16:00–16:30	COFFEE BREAK
16:30–17:30	Energy Audit Equipment Demonstration (Continuation)
17:30–18:00	CLOSING CEREMONIES

REGISTRATION CARD

(Please return the card by **8 February**)
Please mark your attendance with ○

1. First day (Paper)
2. Second day (Glass)

(Kindly print in block letters)

NAME :

JOB TITLE/POSITION:

COMPANY :

OFFICE ADDRESS :

OFFICE TEL./FAX NO.:

For inquiries on this seminar, please contact:

Ms. Helen B. Arias or
Ms. Rose V. Sumulong

Tel 851021 to 31 Ext. 201 or 214
855724

Appendix 5. Textbooks of the seminar

SEMINAR ON ENERGY CONSERVATION IN PAPER INDUSTRY

Sponsored by
United Nations Industrial Development Organization (UNIDO)
and
Ministry of International Trade and Industry (MITI), Japan

Hosted by
The Department of Energy, Philippines (DOE)
Organized by
The Energy Conservation Center, Japan (ECC)

1993
Manila

CONTENTS

1. Production process of the pulp and paper industry

The pulp and paper industry has been consuming much energy and water ever since Cailun (an inventor of paper in ancient China) invented paper in A.D. 105. He crushed the bark of the shrub with a stone mill to extract fibers, and separated the single fibers by washing them in water. When they were uniformly distributed underwater, they were dewatered and formed by a drain board. Then the wet paper web was dried in the sun for a long time, and final paper products were obtained.

The basic principle in the manufacturing process of the pulp and paper industry today has undergone almost no change, but the industry has developed into a process industry constituting the continuous production processes. Figure 1 shows an example of the production process.

The pulp and paper industry consumes much energy and water. The pulp and paper industry is also noted for great percentage of the energy cost in the total production cost.

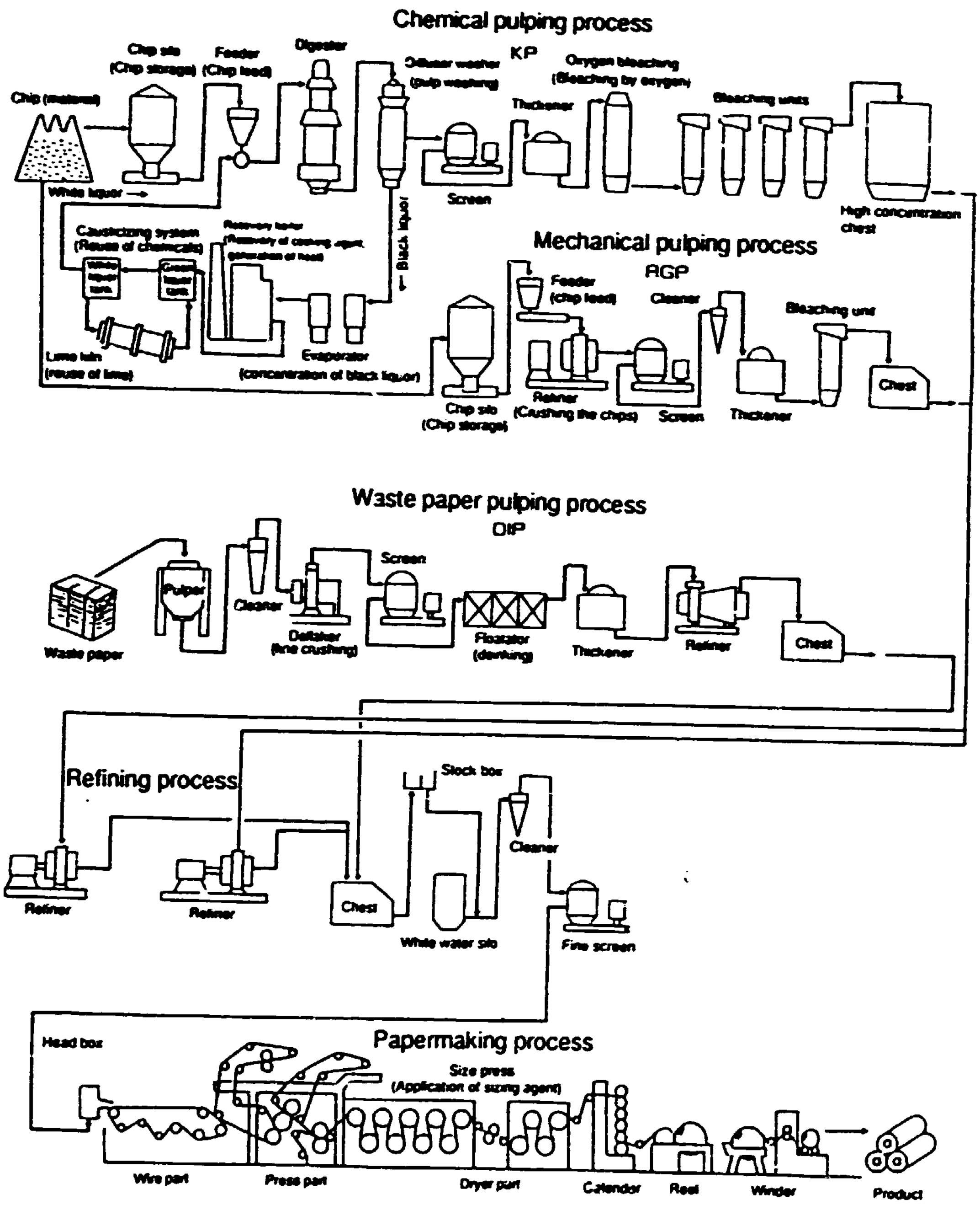


Figure 1 Overview of pulp and paper manufacturing processes

2. Consumption in the pulp and paper production process

It is extremely difficult to grasp the energy consumption pattern in the entire pulp and paper industry. Since the pulp process differs considerably depending on production items and composition of the material woods, it is difficult to define the representative pulping process. Table 1 represents the unit consumption of the consumption pattern of steam and electric power summarized according to the recent data in Japan, using the model of the integrated fine paper mill for general printing paper and writing paper.

Table 1 Energy consumption pattern of pulp and paper processes in an integrated fine paper mill

Energy \ Process		Evaporator Causticizing	Cooking Washing	Bleaching	Paper machine	Others
Steam	ton/paper ton	1.5	1.0	0.4	3.0	0.3
		5.9 (95%)				
		Cooking Washing	Bleaching	Refining	Paper machine	Others
Electric Power	kWh/paper ton	140	150	240	600	220
		1,130 (84%)				

The paper machine, which is the greatest consumer of steam, followed by the black water concentration process, is also the greatest consumer of electric power.

3. Promotion of energy conservation technology

3.1 Waste-saving and effective use of energy

The paper and pulp production equipment as a process plant is operated by electric power and thermal energy. Energy conservation is meant not to reduce the energy for operation, but to ensure "waste-saving" and "effective" use of energy, thereby resulting in reduced energy for operation. "Waste-saving" and "effective" use of energy is ensured by field technology.

"Waste-saving" use is provided by continuous operation from the start of operation to the day of shutdown determined by the production schedule, without the paper and pulp production being interrupted by the machine and steam system failure, electric failure due to accidents, or paper breaking on the paper machine.

This continuous operation requires:

1) Quality control system which permits constant production of stable good-quality products, without products rejected in the inspection, and
2) Preventive maintenance (PM) system which eliminates the possibility of machine and equipment troubles or electric failure due to electric equipment failure.

The so-called total control system must be implemented every day as part of the routine work.

"Effective" use is to prevent dissipation and waste of heat of the energy supplied to the system or to recover it, and to provide uniform hydration in the cross direction on the wire part, press part and dryer part by ensuring the following equipment functions:

1) Improving the rate of circulated use of white water to reduce the wasteful discharge, which leads to reduction of new water used

   The electric power for the pump, agitator and refiner is converted into thermal energy to raise the pulp slush temperature. Discharge of the white water means discharge of heat. Maintenance of a high system temperature by effective circulation of the white water will improve dewatering rate and reduce the amount of steam used for drying. Effective circulation of the white water will also improve yield rate.

2) Uniform nip pressure of the pressure to be ensured in the cross direction
Effective energy reduction cannot be gained by mere pressure increase. Uniform dewatering is ensured only by uniform pressure in the cross direction, which, in turn, will permit uniform drying and minimize the possibility of paper breaking.

3) Three functions of showering, squeezing and dewatering to be used to wash the press felt
The felt cleaned and dewatered to have low-moisture content promotes suction of water in the pressing process. Use of hot water for shower provides effective washing and prevents wet web temperature from lowering.

4) Dryer surface to be kept clean by effective use of the doctor thereby ensuring high heat conductivity

5) Drain within the dryer cylinder to be eliminated completely
Drain has a low heat conductivity, so it decreases heat efficiency.

6) Ventilation inside the dryer part to be uniform on the front and back, dryer pocket in particular to be eliminated completely

3.2 Energy conservation technology in the pulping process

The following describes the concept of "waste-saving" and "effective" energy conservation, with particular reference to chemical pulping kraft process.

Figure 2 shows the case of batch cooking.

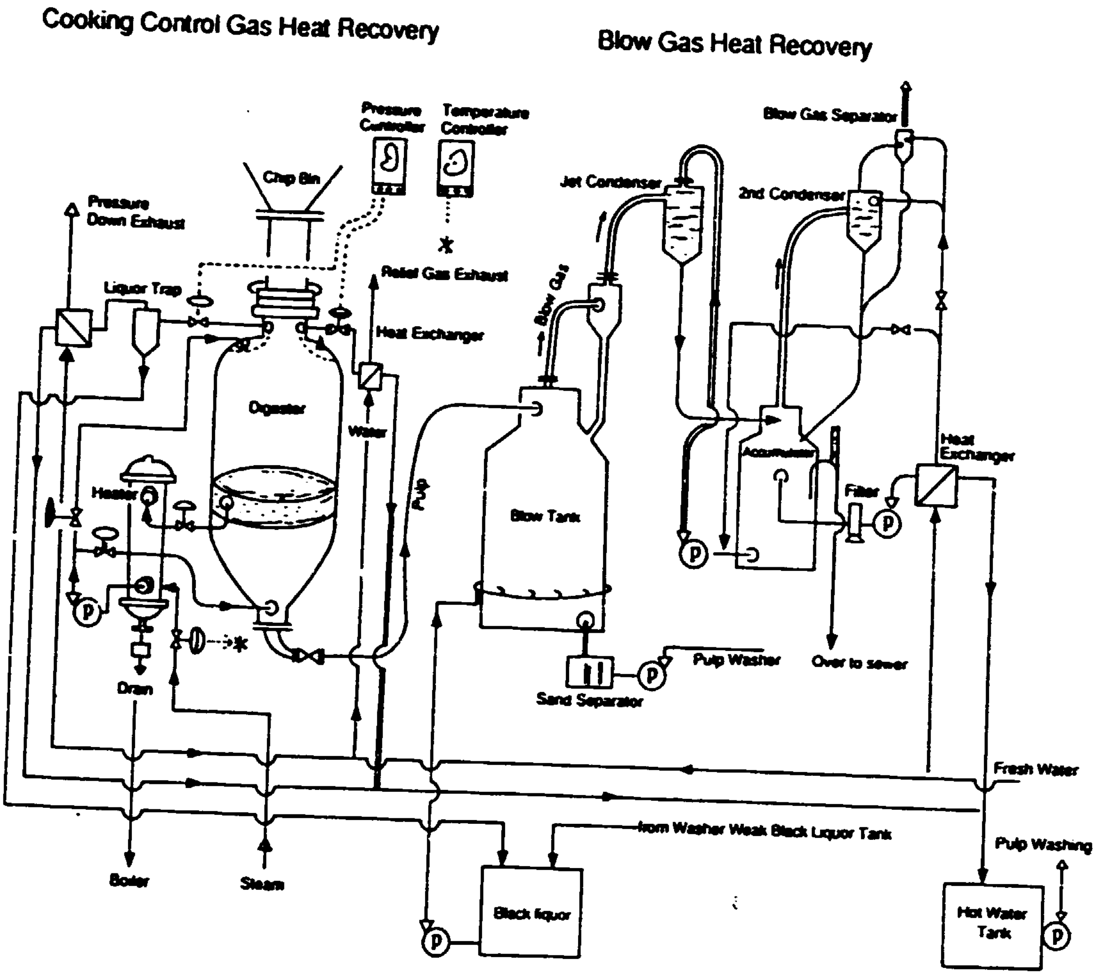


Figure 2 Batch cooking and heat recovery system

Much energy is consumed in the chip pulping reaction.

Heat required for reaction must be given as effectively as possible, and the heat should be removed upon termination of the reaction; otherwise, it may affect the quality and yield. The following points should be noted for this series of reaction:

(1) Rise of reaction temperature

The cooking liquor is heated by the steam of the multi-tube heater, and the temperature inside the digester is raised. In the indirect heating method, scales which have low heat conductivity will be attached on the liquor side of the heater. Since the scales waste steam, attached scales should be removed on a periodic basis.

(2) Control of reaction requirements

When the reaction temperature has risen, non-condensable gas will be produced, preventing the reaction. This gas must be removed. When it is removed, heat contained in the gas is recovered by the heat exchanger.

(3) Pressure reduction

Immediately after reaction, the pressure is reduced and the temperature is lowered. The pressure reducing speed is increased when a great amount of this high-temperature exhaust gas is cooled by the heat exchanger. At the same time, the heat contained in the gas can be recovered as hot water. Scales and pulps are attached to the gas discharging strainers provided on the gas side of the heat exchanger and on the top of the digester, and cause the gas discharge speed to be lowered. Periodic inspection and cleaning are essential to improve the efficiency of the strainer and heat exchanger.

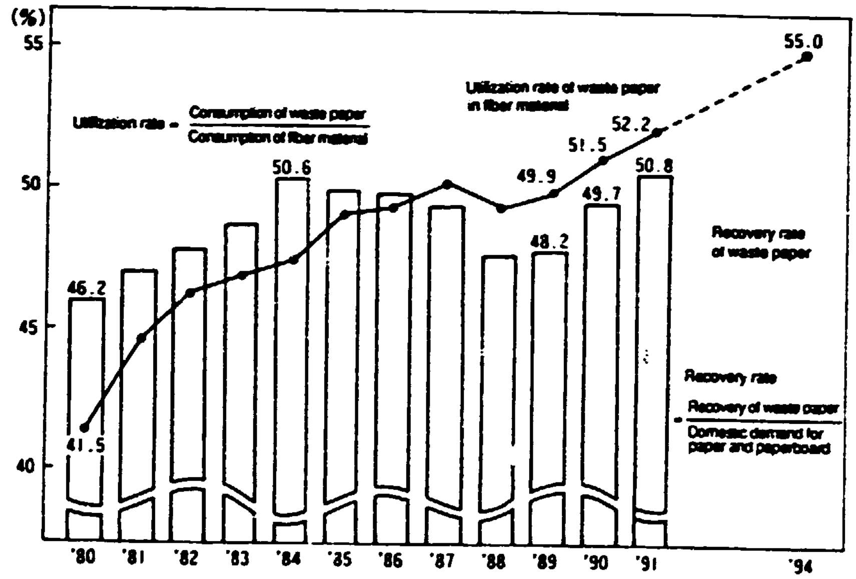
(4) Blowing

When the pulp in the digester is to be blown out by the internal pressure, the blow speed is increased and the blow time is decreased by increasing the differential pressure of the exhaust gas. Pulps are attached to the jet condenser which absorbs a great amount of gas and the thermal accumulator. Pulps also enter the heated dirty water, so they are attached to the heat exchanger for heat recovery. Since the pulps feature extremely small heat conductivity, they must be removed periodically.

For energy conservation in the pulp division, effective supply of energy for pulping must be ensured, and the extra energy required for pulping should be recovered as effectively as possible, and should be put to reuse.

3.3 Use of waste paper in the pulping process

The pulp and paper industry is highly evaluated for its effective reuse of the waste paper and for its attitude toward effective use of precious resources on earth. The waste paper once used only as paperboard has come to be used as newspaper, writing paper and toilet paper by the development of deinking technology (see Figure 1), which has permitted manufacture of the products having almost the same quality as the new one. Such efforts have resulted in the utilization rate and recovery rate of as high as over 50% as shown in Figure 3.



Source: PPI

Figure 3 Recovery and utilization rates of waste paper in Japan

This effort means a great contribution not only to energy conservation, but also to reduction in the amount of refuses generated in the community and reduction in the refuse processing costs, thereby contributing to the global environment protection.

(1) Waste paper pulping

In the deinking process, deinking agent is added after defibration of the waste paper, and the paper is subjected to maturation for a sufficient long time; then ink is removed from the paper by kneading action. The paper is put into the bleaching equipment, from which the deinking pulp (DIP) featuring a high degree of whiteness is obtained.

(2) Energy conservation effect of waste paper

Energy consumption in pulping the waste paper is said to be about one-third that in wood pulping.

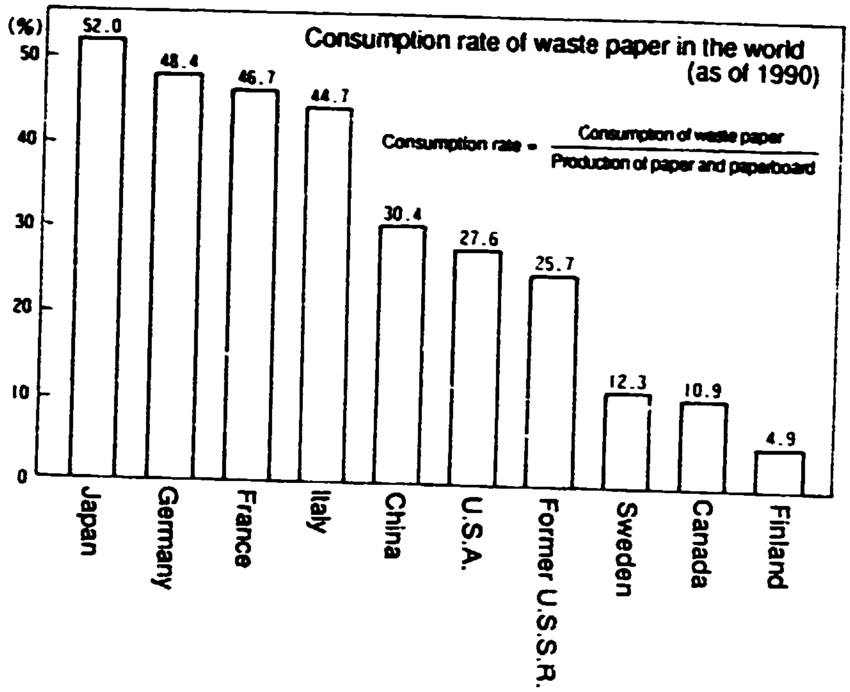
Table 2 illustrates the unit energy consumption for waste paper pulping.

Table 2 Unit energy consumption for waste paper pulping

Pulp	Waste paper \ Unit	Steam Unit: t/pulp t	Electricity Unit: kWh/pulp t
Defiberized pulp	Corrugated container waste	0.025	230
	Old news, old magazines	0	250
Deinking pulp (DIP)	Old news	0.3	400
	Old news, printed wood free	0.3	380

Source: Japan TAPPI Journal

The progress of the technology for effective use of waste paper in the pulp and paper industry is quite remarkable. Figure 4 illustrates the consumption rate in the world. It shows that energy conservation of the pulp and paper industry in the world is making a steady progress.



Source: PPI

Figure 4 Consumption rate of waste paper in the world

3.4 Energy conservation technology in the papermaking process

The pulp and paper industry as a process industry is required to ensure efficient operation, depending on the control method which provides continuous operation. Improvement of the operation efficiency will lead to the effective use of energy and lowering of the unit consumption.

From the viewpoint of operation efficiency, the energy conservation measures can be reduced to the following points:

(1) Measures to prevent electric failure at power companies
(2) Preventive maintenance by the maintenance division
(3) Prevention of paper breaking
(4) Effective use of white water
(5) Improvement of blanket washing equipment, prevention of the blanket and wire net from being contaminated, and material processing measures
(6) Acceleration of press dewatering
(7) Acceleration of evaporation in dryer

It is generally felt that there is no remedy for electric failure. A paper manufacturing company which frequently suffers from power failure adopted a private power generation equipment. Since then, it has ensured a stable supply of power completely free from electric failure. Operation efficiency has been increased, while power cost has been reduced to half that of the purchased power. As a result, sales volume and yield have been improved, enabling the company to achieve depreciation in less than three years. This effort has also contributed to the improvement of power situations in local communities and they appreciate it very much.

The process industry cannot enjoy continuous operation without an effective maintenance division. Preventive maintenance (PM) is to prevent accidents in advance and to repair and improve the equipment by a planned equipment maintenance based on the past experience with the equipment failure and by checking the operation through daily equipment inspection on patrol. It is intended to eliminate the operation shutdown by the maintenance division.

3.4.1 Paper breaking

Paper breaking in the paper machine will lead to waste of energy and reduced yield, causing costs to be increased. It also results in considerable labor consumption. Paper breaking used to be considered as a matter of course: However, after detailed analysis of the paper breaking is carried out, the problem will be greatly reduced as a result of improved operator skill, improved equipment ranging from material treatment to paper making process, and introduction of the instrumentation control.

(1) Analyzing causes for paper breaking

Figure 5 shows a chart for the characteristic factors which cause paper breaking.

Table 3 illustrates the outline list showing causes for paper breaking and their remedies.

Means to eliminate the possibility of paper breaking can be summarized as follows:

(a) Removal of shives, sand and other foreign substances

(b) Improvement of formation

(c) Uniform pressure to ensure high dewatering efficiency

(d) Uniform evaporation and drying

The following points should be noted regarding technical problems involved in the equipment:

a) Selection of the equipment with insufficient functions (selection error)

b) Equipment not operating in conformity to the specifications

c) Neglected maintenance, inspection, repair, or performance checking of the equipment; therefore, required performances not fully used

d) Claim against electric failure not submitted to the section in charge inside or outside the company; technical improvement delayed

It is their duty to check if each function is working, to review the operation method and to improve it if something is wrong.

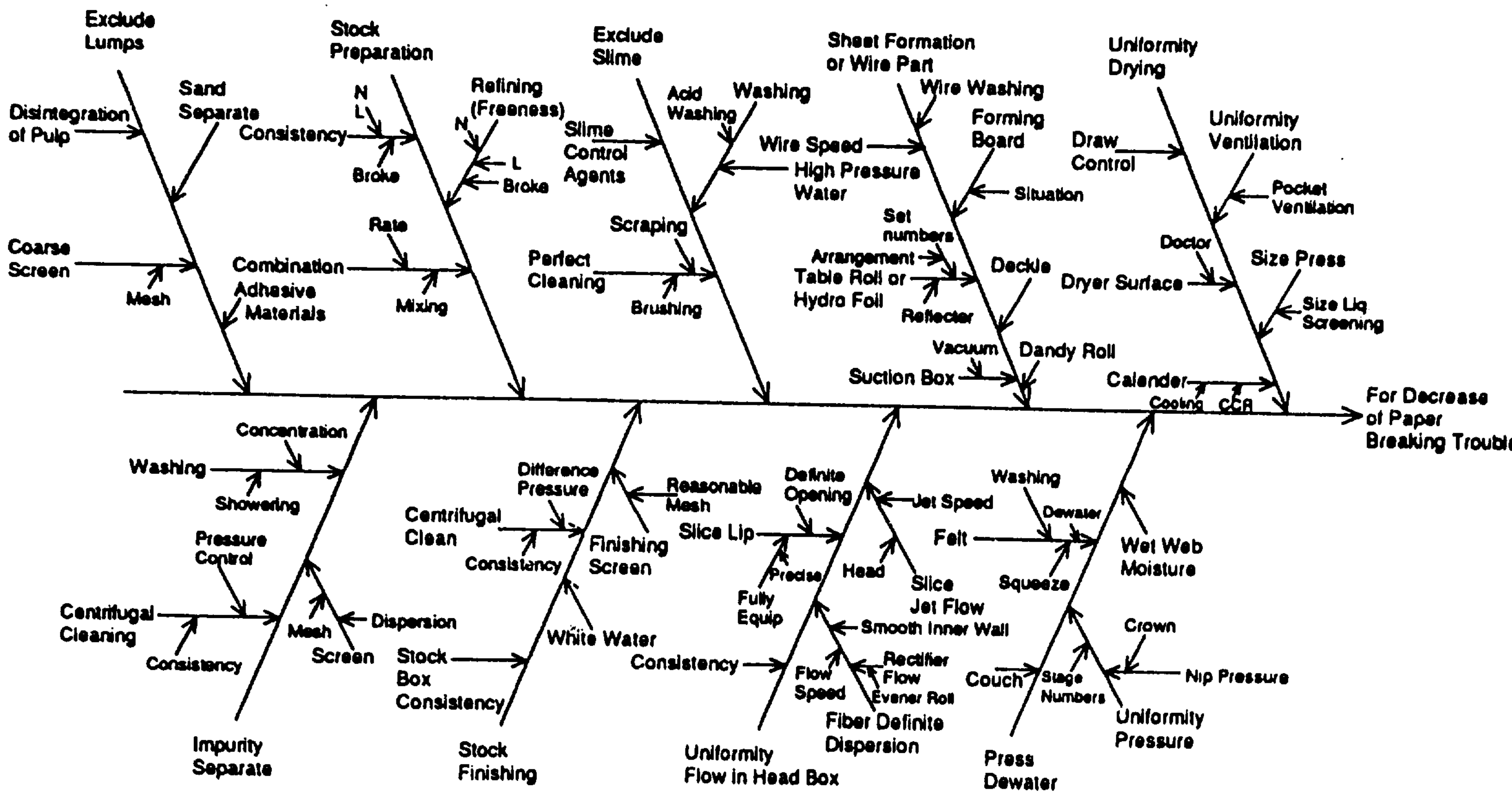


Figure 5 Cause and effect diagram of paper breaking

Table 3 Causes for paper breaking and remedies

Places for paper breaking	Classifications	Causes	Measures	Equipment factors
1. Wet part				
(1) Couch	Fall from couch	Excess Moisture (Wet Insufficient strength)	Promotion of dewatering on wire	Dewater rectify on Wire Part Setup of Pick up roll
(2) Press	Breaking by press	Crushing Roughened surface on plain roll Mixing of slime Mixing of adhesive substances	Promotion of dewatering Roll grinding Removing the slime Separation, removal and dispersion	Grinding Heat kneeding
	Uneven dewatering	Faulty formation Dirty blanket Uneven line pressure	Formation correction Promotion of blanket washing Crown correction	Flow rectify in Head Box & Wire Part Washing, squeeze, dewater, grinding
(3) Wet end	Fall by wetting	Faulty drawing Excessive moisture Mixing of shives Triming water Cutting fault	Drawing adjustment Promotion of dewatering (line pressure increase) Promotion of screening	Setup of high pressure Press Centr. Cleaner, Fine Screen, High Pressure Water Jet
2. Dryer part				
(1) Yankee Dryer	Breaking due to faulty separation	Foreign substance attached Damage on dryer surface	Effective use of the doctor Polishing the surface	Dryer cleaner Bronze Doctor, Dryer Grinding
	Breaking due to intrusion of foreign substances	Mixing of shives and impurities	Promotion of screening	Centricleaner
	Breaking by tension	Faulty drawing Faulty formation	Drawing adjustment Correcting the formation	Flow rectify in Head Box & Wire Part
(2) Multi Dryer	Breaking by tension	Faulty drawing between groups	Drawing adjustment	
	Edge breaking	Edge too dry Mixing of shives and impurities Trimming water cutting fault	Improvement of dryer pocket Promotion of screening Water pressure increas	Pocket Ventilation Centricleaner, Fine Screen
3. Calender part	Crushing Breaking by foreign substances Breaking in longitudinal directions	Faulty formation Incorrect roll crowing Mixing of shives and impurities Faulty formation and wrinkling Unevey drying and wrinkling	Correcting the formation Correct the roll crowing Promotion of screening Improvement of dryer ventilation Correcting the formation Removing the dryer pressure	Flow rectify in Head Box & Wire Part Grinding Centricleaner, Fine Screen

3.4.2 Impurities

Shives, sands, pitches, slimes and deposits are defined as impurities.

Each of the pulping process, material pre-treatment process and papermaking process is provided with the device to remove the impurities. This is because too many troubles are caused by the impurities, and these are very difficult to remove.

(1) Troubles due to impurities

(a) Paper breaking may be caused by tension in the contraction process during wet web drying if impurities are located at the sheet edge.

(b) Even if pressure is applied to impurities by the press, they contain much moisture and will produce black spots (fish eyes). To remove them, they must be overheated inevitably.

(c) This may cause reduction of printing efficiency and even damage of the plate cylinder when the user is printing. This may be the cause for claims against product quality.

Paper breaking will reduce efficiency, yield and production volume, leading to great energy loss. Fish eyes are often accompanied by much energy consumption due to over-drying; they cause much curling, poor paper quality and lower yield.

(2) Impurity removing measures

(a) Equipment

The coarse screen, centrifugal cleaner and material finishing screen for material pre-processing have pressure and consistency suited to the equipment type. Without relying on the manufacturer specifications, measure the dust removal rate according to the requirements of the process in the plan, and set up the appropriate work standards. Figure 6 illustrates the typical centrifugal cleaner.

The technological advance of the finishing screen is quite remarkable; the slit of 0.07 mm has appeared, contributing to improved quality and reduced paper breaking.

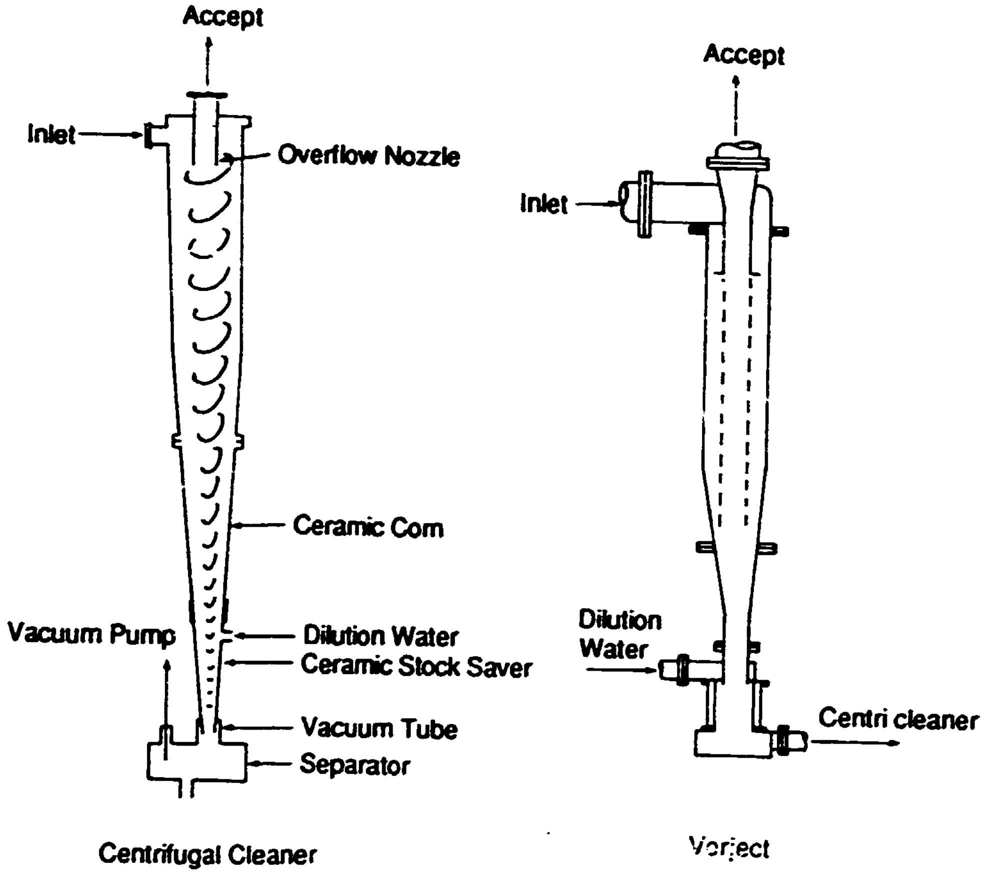


Figure 6 Centrifugal cleaner

(b) Multi-stage removing of impurity

The multi-stage equipment is used when the impurity cannot be removed completely by the one-stage equipment. The impurity removal ratio is measured, and the equipment of the subsequent stage is installed for the existing equipment, to provide a multi-stage configuration featuring sufficient capabilities. This will improve the pulp yield and quality and prevent paper from breaking, ensuring improved overall yield.

(c) Removing the slime and deposits

The refining process and papermaking process provide the optimum conditions for the growth of microorganism, and deposits are formed in many places. Especially the deposits are formed at the positions which are invisible. Deposits must be removed periodically from the following positions by manually brushing or by scraper:

a) From the fan-pump (large volume and low head pump) to the piping leading to the head box
   This position should be provided with the flange connection to facility cleaning.
b) From the inside of the head box to the lip
   Use the wooden scraper so that inner faces will not be damaged. (It must be prepared for this purpose).
c) Side wall of the forming board under the wire, table roll journal, hydro foil, back of the deflector and inner and outer surfaces of save-all devices

The amount of slime will be increased if the amount of the circulated white water is increased, and temperature within the system is raised. When the temperature has reached 45°C or more, there will be no growth of deposits.

Note that the slime control agent is not an inhibitor; it does not remove the slime. It should be used for a long-time continuous operation.

3.4.3 Press dewatering

Dewatering in the papermaking machine is achieved by increasing the nip pressure and to apply it uniformly in the cross direction. To ensure effective use of the equipment function, repair, maintenance and adequate modifications must be provided at all times. Care should be taken in the daily control to assure that the press blanket is elastic enough to have a sufficient sunction force.

(1) Effect of press dewatering

Reducing the wet web moisture by 1% after pressing saves the drying steam of the drier by 4%.

$$W\ (kg) = \frac{(Pw - Dm)}{(1 - Pw)} = \frac{(\text{wet web moisture \%} - \text{paper moisture \%})}{(\text{paper bone dry \% of the wet web})}$$

where,

Pw (%): wet web moisture at press part outlet
Dm (%): wet web moisture at dryer part outlet
W (kg): amount of moisture evaporated from 1 kg of dm% paper

The average of values in the cross direction is used as moisture. The sample should be collected by dividing the total width into several equal parts, and is used for adjustment of moisture deviation and improvement of the press.

Table 4 shows the moisture evaporated from Pw% of wet paper in the production of 1 kg of paper, when paper moisture at the dryer end (Dm) is 5% or 10%:

Table 4

Pw %		65	64	63	62	61	60	59	58	57	56	55
W (kg)	paper moisture: 5% (Dm)	1.71	1.64	1.57	1.50	1.44	1.38	1.32	1.26	1.21	1.16	1.11
	paper moisture: 10% (Dm)	1.67	1.50	1.43	1.37	1.31	1.25	1.20	1.14	1.09	1.05	1.00

When the wet web moisture is decreased from 57% to 56% at the press part, where paper moisture is 5%,

$$\frac{1.21 - 1.16}{1.21} \times 100\ (\%) = 4\%$$

Thus, drying steam is reduced by 4%.

Paper moisture of 5% is not effective when consideration is given to yield.
Assuming the uniform line pressure to be applied in the cross direction, and uniform drying and paper moisture of 10% to be obtained with moisture at the press outlet being 57%, we get the following:

$$\frac{1.21 - 1.09}{1.21} \times 100\ (\%) = 9.9\%$$

This will save steam for drying by about 10%. Furthermore, the yield is also improved by 5%. Combined with the advantage of energy conservation, substantial cost reduction is achieved.

(2) Other effect of improving the dewatering rate

For the mechanical pressure of the press, the following advantages are obtained by improving the density between the paper layers:

a) The strength of the wet web is increased, and breaking of the wet web between press part and dryer part is minimized.

b) The surface strength is improved, and the shives attached to the dryer surface are reduced in numbers, ensuring higher paper quality.

c) Uniform dewatering removes sag from the open draw part, and dryer wrinkles are minimized.

d) The tensile strength, bursting strength and smoothness of the paper are improved.

(3) Major point for press part dewatering rate

Figure 7 shows the factors causing press dewatering:

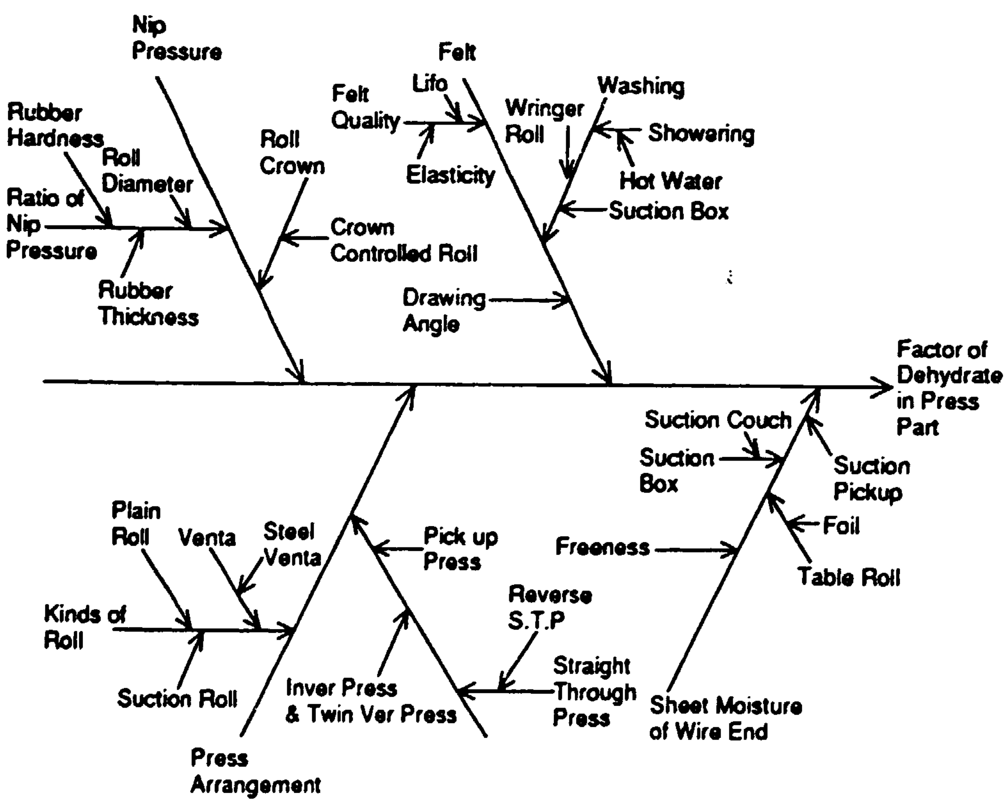


Figure 7 Cause and effect diagram of press dewatering

a) Nip pressure and specific nip pressure

When the nip pressure is increased in regular succession, paper moisture is reduced up to twice or three times. After that, the change becomes smaller and smaller until there is no change at all.

The nip pressure effect should be considered as specific nip pressure (nip pressure/nip width).

The nip width depends on the diameter of the rubber role and the hardness and wall thickness of the rubber. To improve dewatering rate in the current equipment, the first thing to do is to measure by experiment the locus of the nip width according to the current nip pressure and changed nip pressures and moisture rate divided into several equal parts in the cross direction. This experiment provides the improvement measures to increase the specific nip pressure (nip pressure (kg/cm)/nip width (cm)), the rubber hardness and rubber thickness. The locus of the nip width can be identified by color development after application of pressure by inserting the no-carbon paper or special-purpose nip check sheet between the top roll and bottom roll. It can also be used to adjust the roll crown.

b) Roll crown

A pair of top and bottom pressure rolls serve as beams to support both ends, and are bent downward by their own weight. When load is applied to the journals on both ends of the top roll, the roll will bend upward. This brings both ends of the rolls into close contact with each other, but a clearance occurs at the center. As illustrated in Figure 8 (A), the locus of nip width is formed. The roll crown for ensuring uniform dewatering should be determined so that accurately rectangular form as shown in Figure 8 (B) will be obtained, having such nip width as obtained from the product quality, papermaking machine, papermaking speed and analysis of the current situations.

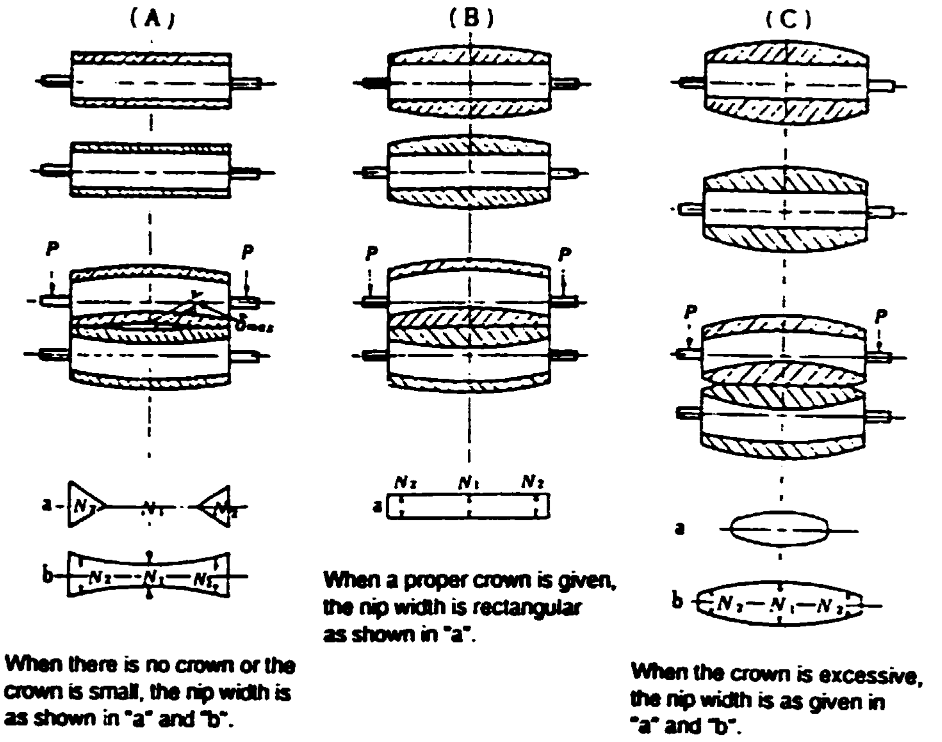


Figure 8 Roll crown and nip width locus

c) Press roll and part arrangement

The press where both the top and bottom rolls are made solid are called "plain press". The press where one or both of the top and bottom rolls are suction rolls is called "suction press" (See Figure 9). The "Venta press" is the press which uses the bender roll (or grooved roll) the surface of which is provided with grooves. Various arrangements are made on the press part which has a great energy conservation effect.

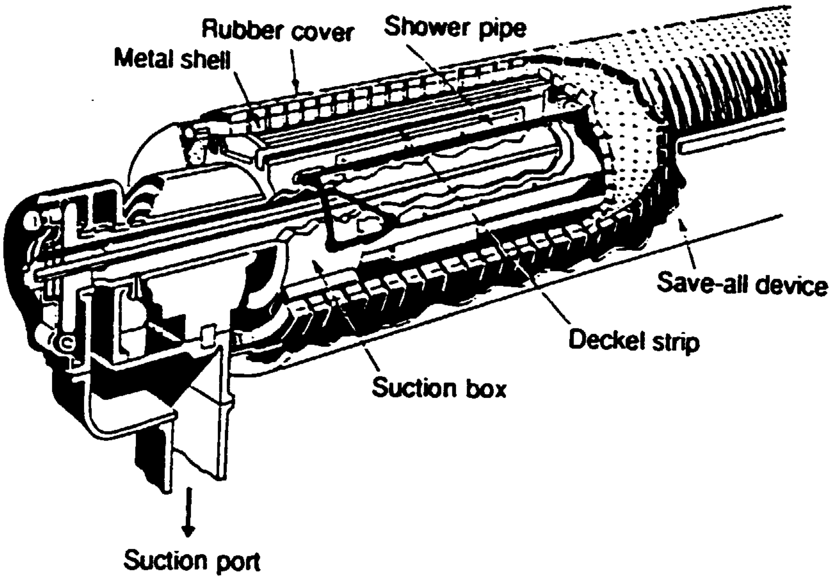


Figure 9 Suction roll

The most fundamental type is the straight-through press, which is available with many features; reduced installation area, equipment cost and power cost, prevention of paper breaking, and improved paper surface. Figure 10 shows the typical arrangement.

d) Felt

To minimize water passing resistance and to ensure elasticity of the press felt, it is necessary to wash the felt to remove contamination and to remove excessive moisture.
Using the recovered hot water for washing shower is effective not only to increase washing efficiency but also to reduce the wet web temperature.

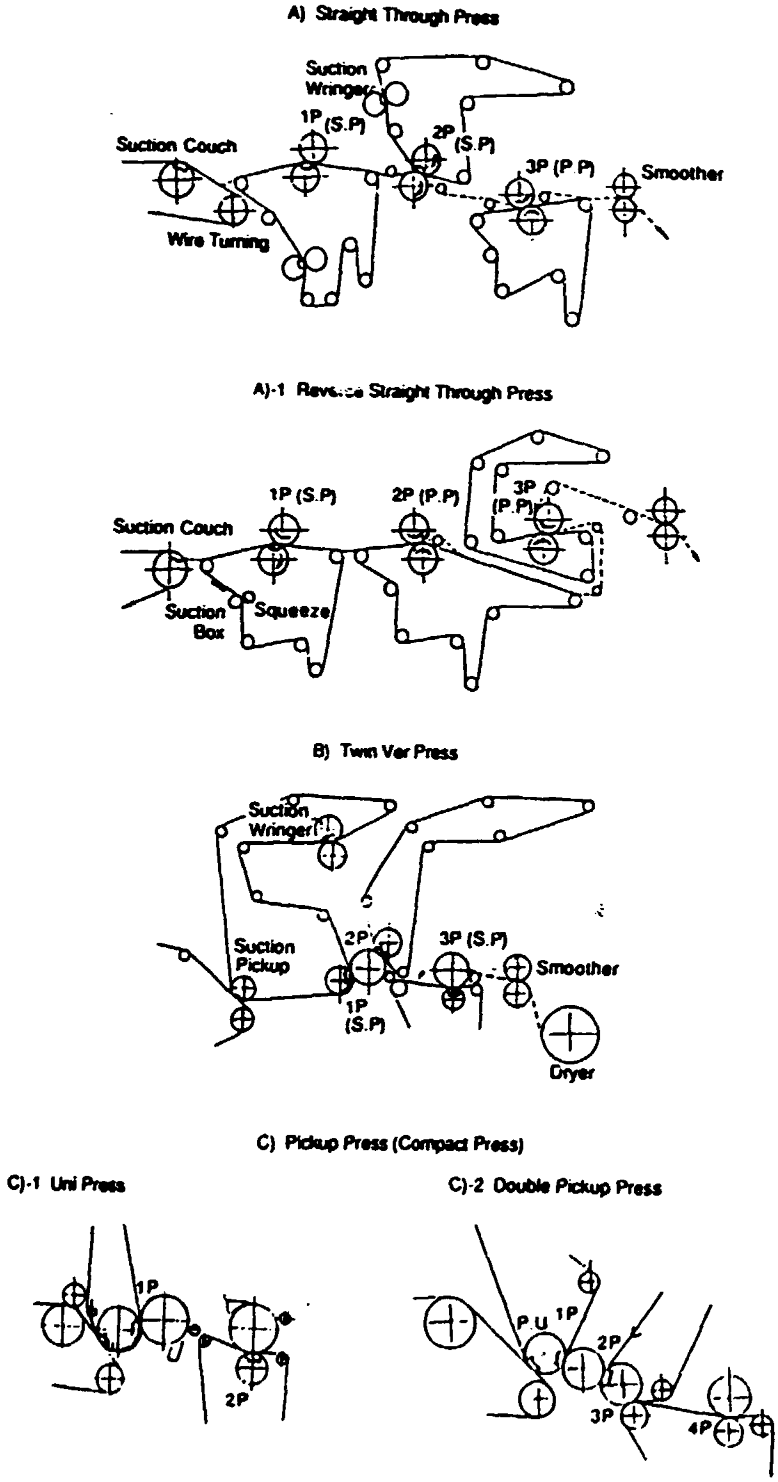


Figure 10 Typical press part arrangement

3.4.4 Effective use of white water

There is a close relationship between energy and water consumption in the pulp and paper industry.

Reuse of white water to reduce the amount of new water to be used is a big problem in the low-consistency papermaking process, and is one of the great tasks and responsibility for the engineers engaged in the pulp and paper industry. There is no equipment which removes fine fibers and filler from a great amount of white water completely and continuously.

The use of new water can certainly be reduced if unique technologies are established by creative consideration for the current equipment and newly introduced equipment according to each kind of products and process.

The pulp and paper industry in the world is making efforts to reduce the amount of water to be used. Table 5 shows the transition of the unit water consumption of the paper mill in Japan.

Table 5 Transition of the unit water consumption of the paper mill in Japan

Kind of paper \ Year	1970	1980	1990
General paper (ton/paper ton)	150	95	85
Paperboard (ton/paper ton)	100	50	45
Tissue paper (ton/paper ton)	200	150	120

The unit water consumption of this industry was about 200 tons/paper ton by around 1960, so the value is reduced to a half at present 30 years after that.

Table 6 shows the transition of the unit water consumption in a typical integrated pulp and paper plant where about 150,000 tons of the bleached kraft every year are produced from the wood free paper.

Table 6 Transition of the unit water consumption and head box temperature

	1960	1990
Unit water consumption (ton/paper ton)	175	87
Head box temperature (°C)	20	45
Paper machine unit steam consumption (ton/paper ton)	3.6	2.8

It should be noted, however, that composition of the product types and quality manufacture requirements are considerably different, and the production volume is also doubled during this period. The annual average water intake temperature is 15.5°C. The rise of the head box temperature indicates the use of circulating white water, thereby reducing the use of new water.
It occupies 20 to 30% of the unit steam consumption of papermaking machine.

(1) White water belongs to resources.

Power of pumping up, chest agitator operation and refining is converted into thermal energy, and is stored in the system, where its temperature is increased. Then it is used for steam adjustment.

The white water separated by the concentration filter and wire of the papermaking machine contains fibers and filler, which can be used as materials again.

(2) Major points for white water reuse

The quality and manufacture requirements are different according to each plant, so properties, distribution and freeness of the temperature, concentration, pH value, fibers, filler, etc. are also different. Recovered materials, application of the white water, product quality after use, the manufacturing requirements for fibers must be studied, based on the current analysis value, settling test, and filtering test. Based on the result of this study, flow sheet (See Figure 11) and material balance, water balance (See Figure 12) are prepared. Improvement of the existing equipment and introduction of the new equipment should be determined by careful study, with consideration given to the opinion of the operator.

Even the equipment which has been installed with consideration given does not always produce the performance as planned. It is necessary to make the most effective use of the equipment by repeating the so-called P-D-C-A method (collection of the data and its analysis), as well as improving the equipment. This is the technique. The effective use of white water has the advantages of improved yield, reduction of drain, and reduced drain disposal cost in addition to energy and water conservation.

Figure 11 shows the lifted type fiber recovery machine in the flow sheet, while Figures 13 and 14 illustrate the fine fiber recovery filter.

Figure 12 gives the material balance and water balance around the papermarking machine in terms of model (wrapping paper of 55 g/m², with the daily production of 100 tons, and total efficiency of 100%).

When the shower in the head box and wire washing water (new water) are replaced by the clean white water treated by the white water recovery machine and sand filter, the head box temperature can be increased up to the value of the stock box.

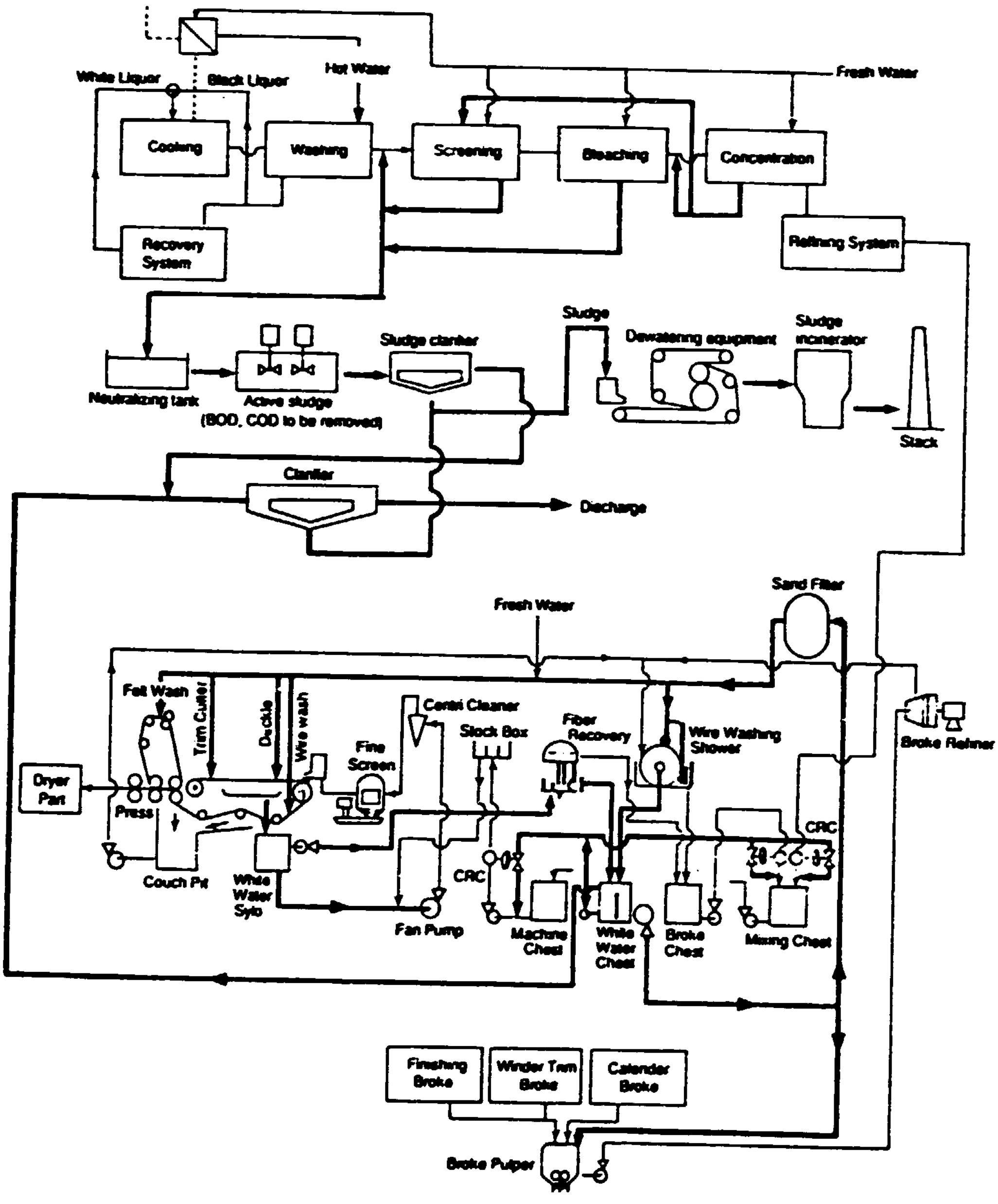


Figure 11 White water recovery and water discharge

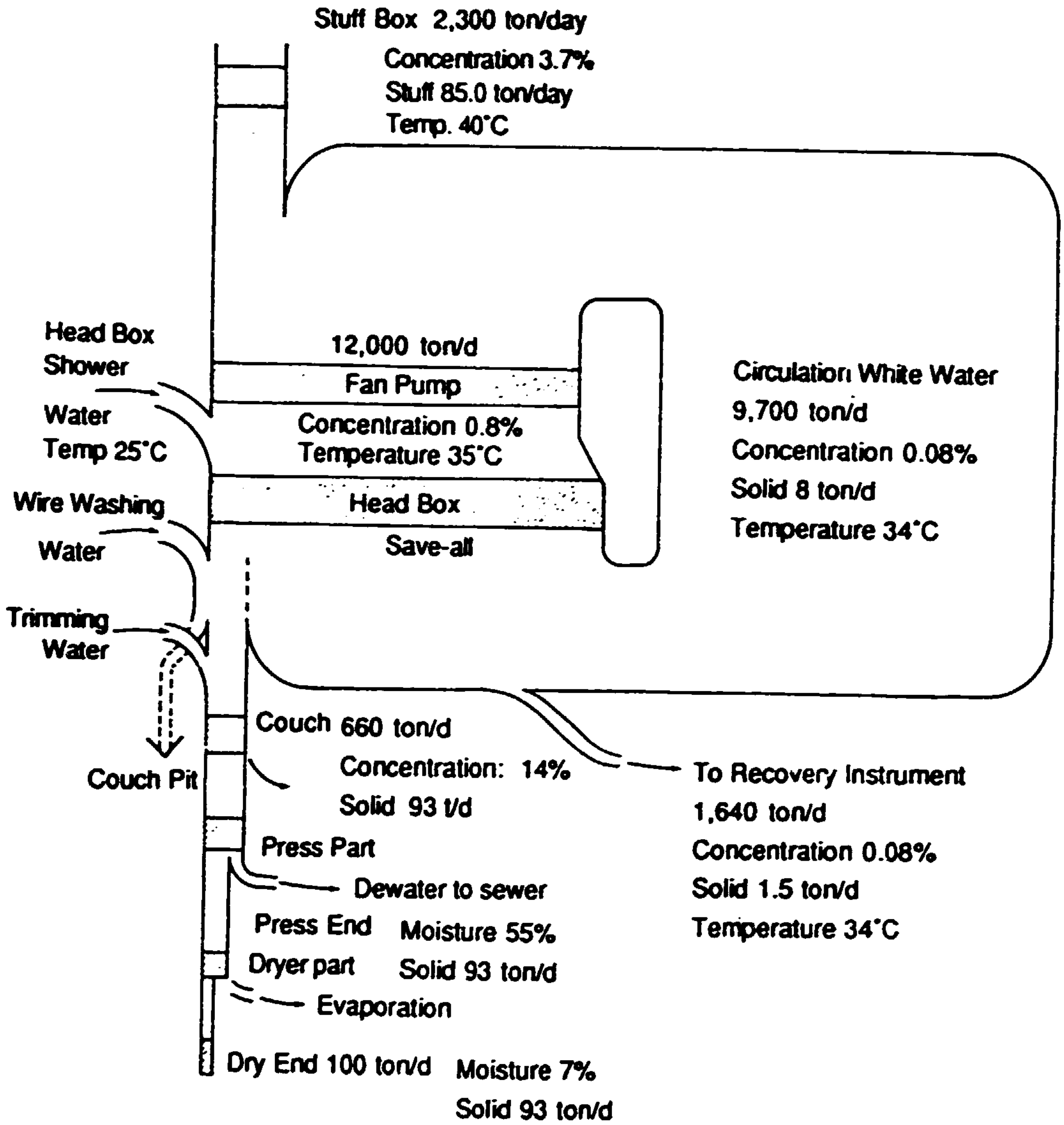


Figure 12 Typical water balance sheet of paper machine

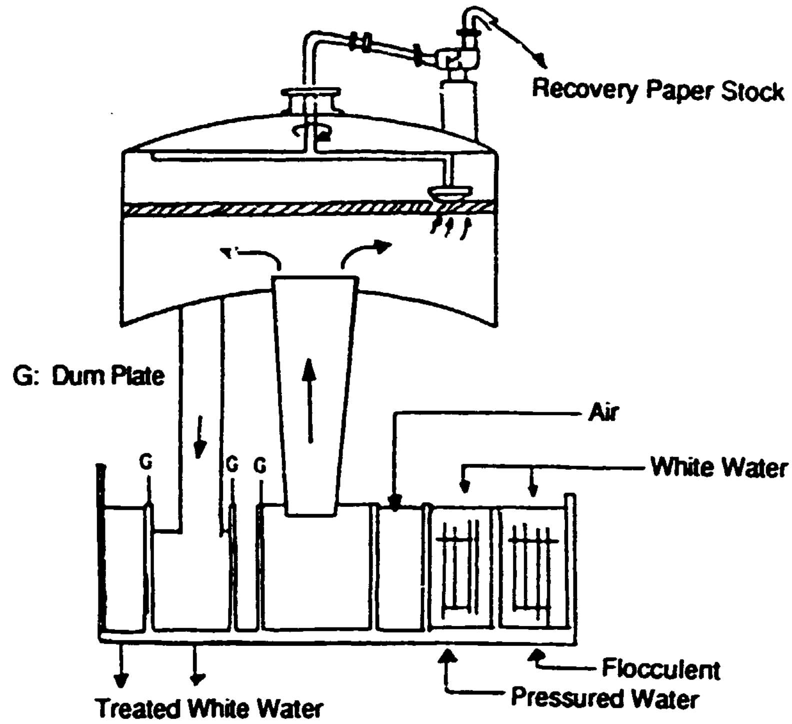


Figure 13 Adka save-all

A) Construction Drawing

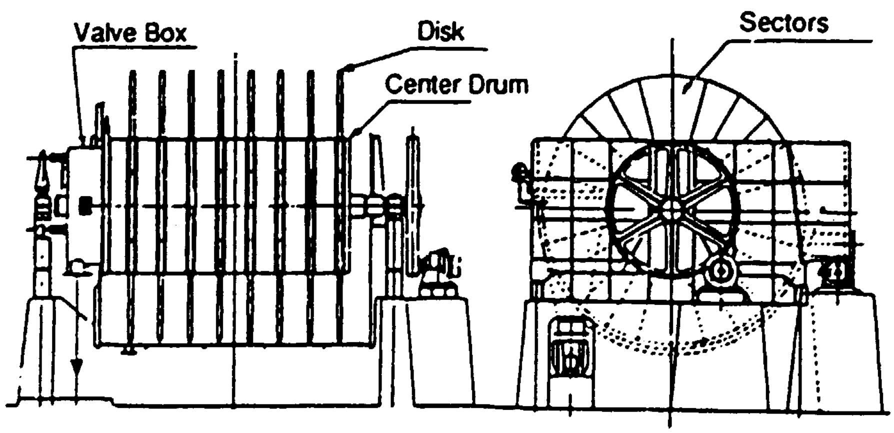


Figure 14 Polydiskfilter

3.4.5 Drying

The dryer is the greatest heat consumer in the pulp and paper industry. It is necessary to evaporate almost the same amount of water as the volume of the produced paper. The following introduces the outline of the factors and measures for effective transfer of supplied energy to the wet paper and efficient evaporation:

Evaporation factor	Measures	Major points
Heat conductivity	Cleaning on the dryer surface	Effective use of the doctor to remove attached foreign substances
	Discharge of drain and non-condensable gas from the cylinder	(1) Effective use of the drain discharge syphon (2) Drain and air has poorer heat conductivity than cast iron.
Uneven drying	Pressure control	Pressure control Section and header pressure detection
	Temperature control	Temperature control Detection of surface temperature by sensor
	Installation of BM meter	Measurement and control of paper moisture, weight, thickness
Ventilation	Adjustment of air flow line inside the dryer	Correction of hood form
	Reduction of thermal resistance, promotion of dispersion	Higher air temperature for dispersion Lower humidity and higher speed
	Removing the dryer pocket	Ensuring uniformity in the cross direction

(1) Adjustment of ventilation

The air speed is likely to increase on both edges of the traveling wet sheet of the multi-cylinder type dryer, then, effective drying goes on. A ventilation pocket is formed at the center, so evaporation and drying delay. Accordingly, contraction starts first at both edges featuring quick drying, and tension load is applied to both edges and paper breaks. If there exist shives, sands, slime, deposits and other impurities at the edges, paper is very likely to break.

(a) Ensuring uniform moisture

To obtain uniform moisture profile in the cross direction in the drying process after paper-making process, it is necessary to meet the requirements of the following intermediate product quality:

- uniform and satisfactory formation on the wire, and
- uniform moisture profile in the cross direction on the press.

After that, ventilation can be controlled easily.

(b) Ventilation control

Figure 15 illustrates air flow inside the open hood among different dryer hood types and moisture profile in the cross direction.

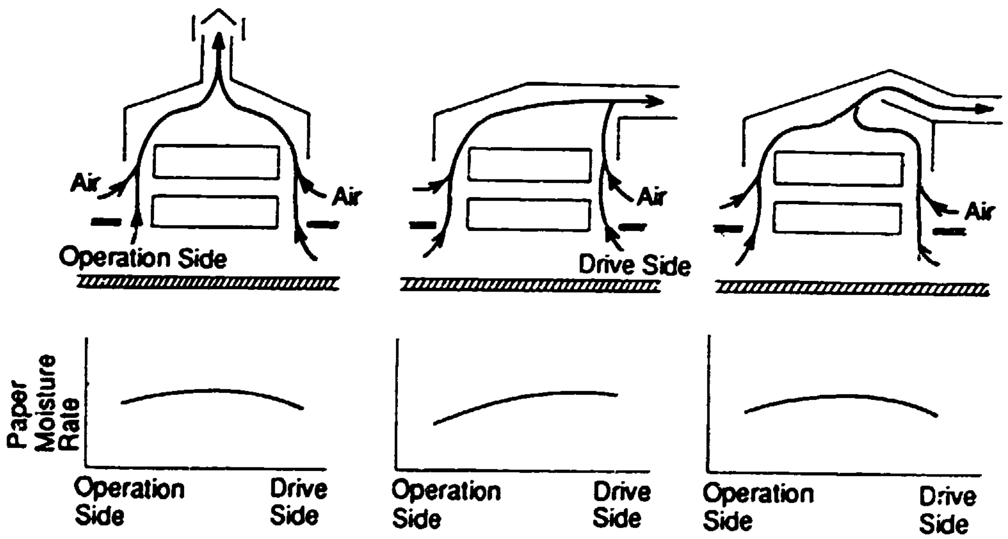


Figure 15 Air flow or paper moisture profile in different hood types

(2) Effective use of BM meter

The BM meter is used to control the moisture profile in the cross direction. This is a device to control the profile within the specified range by the combination of basic weight and moisture percentage sensors with the computer, while scanning in the cross direction. Basic weight control is made in the cross direction and machine direction simultaneously. For the control in the cross direction, calculation is made by the computer, and fan-pump speed control or the opening angle of stream flow valve is controlled. Control in the machine direction is made by manual adjustment of the siice lip.

Moisture is controlled by steam pressure control of the dryer section header.

The profile in the cross direction is controlled by the crown control roll (CCR) so that the press nip pressure is uniform. It should be noted that the complete advantages of the BM meter can be used only when the pocket ventilation device is installed.

4. Energy conservation in the pulp and paper industry

To meet economic growth, market quality requirements are getting more severe and diversified. These quality requirements often make it essential to use much energy. Figure 16 shows the trend of the energy conservation under this situation.

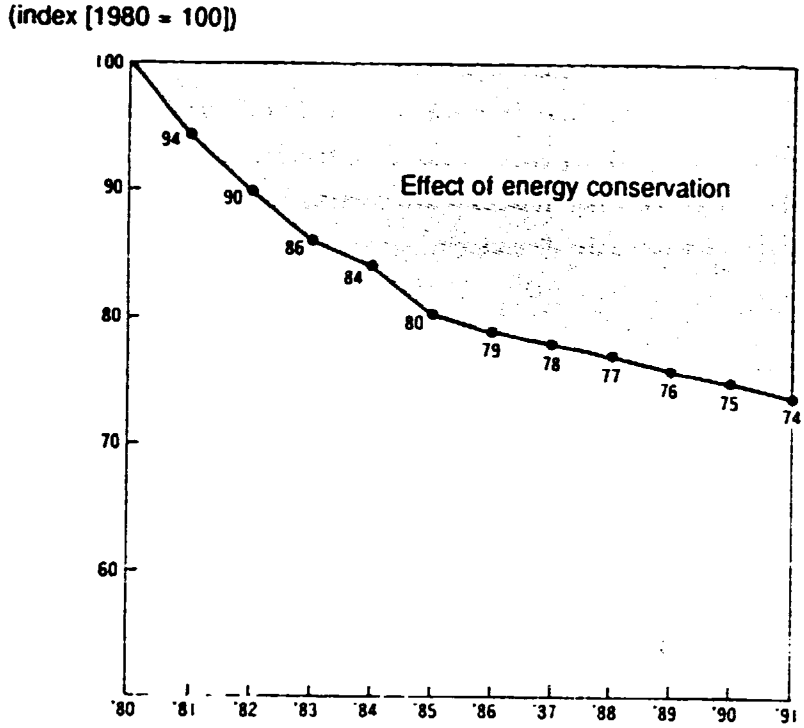


Figure 16 Transition of unit consumption in Japan

For the solution of the problem, the papermaking process mainly depends on increased efficiency, while the pulping process depends on equipment improvement.

4.1 Energy conservation in the papermaking process

Table 7 shows the energy conservation in the papermaking process regarding steam and electric power unit consumption for the paper and paperboard, and this data is based on replies from the questionnaire sent by Japan Paper and Pulp Technology Association.

Table 7 Steam and electric power unit consumption rate for the paper and cardboard manufacturing process in Japan

Type (Unit consumption rate / Fiscal year)		Steam (ton/paper ton)		Electric power (kWh/paper ton)	
		1980	1988	1980	1988
Paper	Newspaper	2.0	1.8	550	530
	White glazed paper	3.1	2.8	1060	940
	Printing paper	2.5	2.3	760	700
Paperboard	Jute liner	2.3	1.8	500	440
	Coated manila board	2.9	2.5	400	540

Printing paper and coated manila board are required to meet severe quality requirements on suitability to printing. Energy conservation is carried out smoothly, though many factors are contained which are disadvantageous to the unit consumption rate. This is due to the efforts for efficiency improvement based on the following management policy:

"Followed by sales people, the production program with major emphasis placed on operation efficiency of the paper machine"

The production plan in the factory is worked out by studying how to reduce the manual replacement time, while major emphasis is placed on the order of manufacturing processes. The sales people facing users promote sales activities according to this plan, and this uniform concept also promotes the field technology in results.

For the newspaper and printing paper, continuous operation for 25 to 40 days is normal. Paper breaking occurs only 0.1 to 0.2 times a day, according to some reports. Further efforts for higher efficiency and effective use of the white water will be made.

4.2 Energy conservation in the pulping process

Energy conservation in the pulping process has registered a remarkable record in KP method (kraft pulp). Transition of the unit consumption is as shown in Table 8.

In the pulping process, introduction of the new equipment leads to reduction of the unit consumption.

Table 8 Comparison of specific energy consumption for KP pulping

		Steam Unit: t/pulp t		Electricity Unit: kWh/pulp t	
Cooking	FY	1980	1988	1980	1988
	N	1.2	1.0	230	220
	L	1.0	0.8	130	120
Evaporation	N	1.5	2.0	100	90
	L	1.9	1.4	100	90
Bleaching	N	0.8	0.4	260	220
	L	0.6	0.3	170	140

(1) Cooking process

One of the major factors for the reduced unit consumption in the cooking process is parallel installation of continuous digesters in many cases. Table 9 shows comparison of unit consumption for batch digester and continuous digester.

Table 9 Comparison of specific energy consumption in batch digester and continuous digester

		Steam Unit: t/pulp t		Electricity Unit: kWh/pulp t	
Batch Digester	FY	1980	1988	1980	1988
	N	1.45	1.3	200	215
	L	1.1	1.1	120	115
Continuous Digester	N	1.1	0.75	240	220
	L	0.9	0.7	130	115

The continuous digester has smaller steam consumption but greater power consumption than the batch digester.

Yearly reduction of unit consumption for steam and electric power is due to gradual improvement of the continuous digester and its operation technique.

(2) Concentration process

Table 10 shows the difference between the unit consumption for steam and electric power of tube type and plate type for the black water concentration evaporator. Since the plate type is based on gravity flow, the pump power is small, permitting easy turning down, quick removal of scales and high operation efficiency.

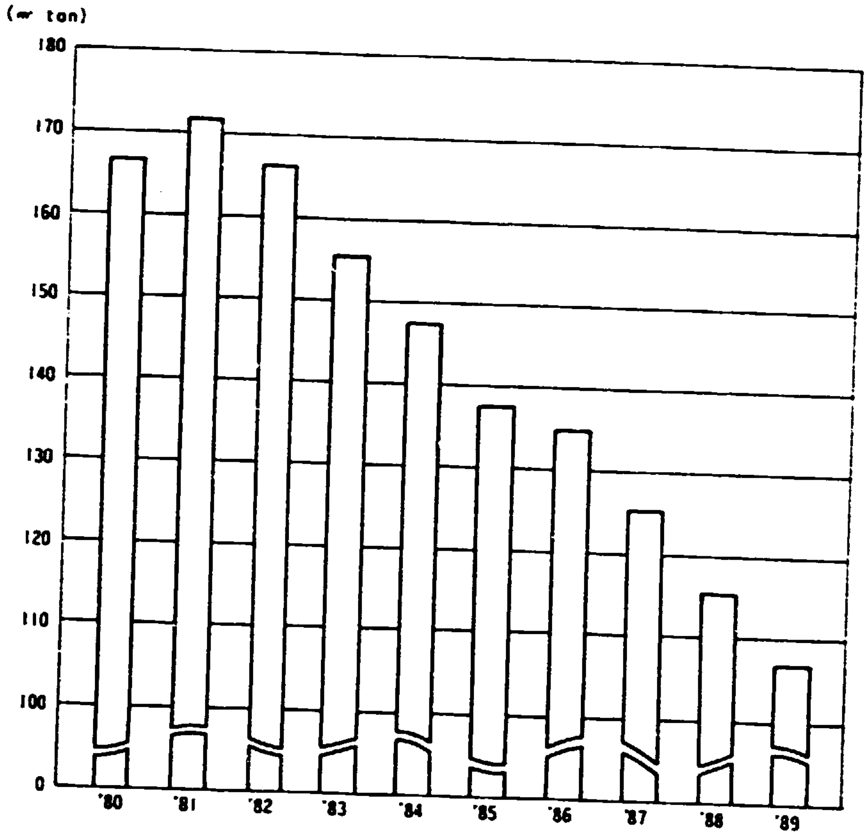
Table 10 Comparison of unit energy consumption for KP pulping

		Steam Unit: t/pulp t	Electricity Unit: kWh/pulp t
Tube type	N	1.7	125
	L	1.65	90
Plate type	N	1.4	75
	L	1.25	80

(3) Saving new water

In Japan the amount of water used recorded a remarkable decrease since about 1970 when the pollution prevention law was enacted. This trend was accelerated further when Japan faced the primary and secondary oil shocks in 1973 and 1978 respectively. Figure 17 shows the transition of unit consumption for the amount of new water used to manufacture paper and paperboard products.

The use of circulating white water has increased head box temperature to 40 to 60°C in many cases. The improved dewatering efficiency and steam unit consumption have also made a great contribution.



Source: Industrial Statistics Table, Volume for Land and Water, Year Book of Paper and Pulp Statistics

Figure 17 Transition of unit consumption for the amount of new water used to manufacture paper and paperboard products

SEMINAR
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IN
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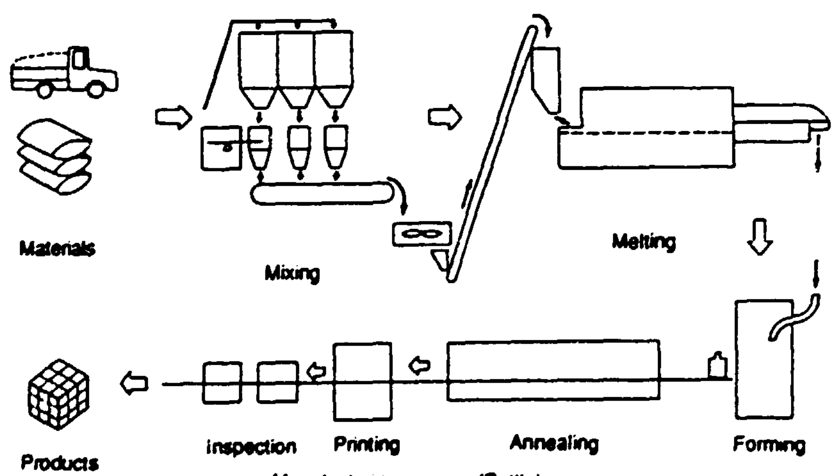
1. Production process of the glass industry

The glass industry consumes much energy. Fuels are burnt to create a high temperature inside the furnace, where the batch is reacted, vitrified, degassed, homogenized, and taken out as products (e.g. glass bottles, tableware). The products are put into the lehr for annealing, and the surfaces are printed as required. Then they are placed into the baking furnace. Thus, each of these processes uses a furnace which consumes much energy. Typical manufacturing process of bottle is shown in Figure 1.

The fossil fuels (coal, petroleum, natural gas) as energy resources are limited resources, which must be left for the people of next generations as much as possible. SOx and NOx are discharged into the atmosphere by combustion of the fuels, thereby affecting the human health. This has raised serious problems. In recent years, CO_2 generated in huge amounts is said to cause global warming, and the impact on the earth environment is getting serious. To cope with this situation, efforts have been made throughout the world to reduce the amount of CO_2 generated with the target placed on the year 2000.

Energy saving or energy conservation efforts in industrial activities are directly connected to the effect of controlling the cost increase due to reduction of unit energy consumption in the industry, leading to intensified competition. At the same time, such efforts provide an essential means for the improvement of the global environment so that the human being will maintain health for a long time to come. It is imperative for the industrialist to understand that the energy conversation is one of the most important policies for the industry, nation and world.



Manufacturing process (Bottle)

Figure 1

2. Characteristics of energy consumption in the glass production process

Figure 2 illustrates the ratio of energy cost on the total manufacturing cost at glass bottle manufacturing plants in 1973 immediately before the first oil shock and in 1981 after the second oil shock. Despite the energy conservation efforts, the ratio rose from 9% in 1973 to 16.7% in 1981 mainly due to spiraling oil cost. This exnlains why further efforts for energy conservation are required.

The energy cost can be broken down as follows:

Heavy oil	11%
Electric power	4%
LPG	2%

Energy conservation for each energy source is a major task to be solved for cost reduction. Figure 3 shows the energy consumption for each process.

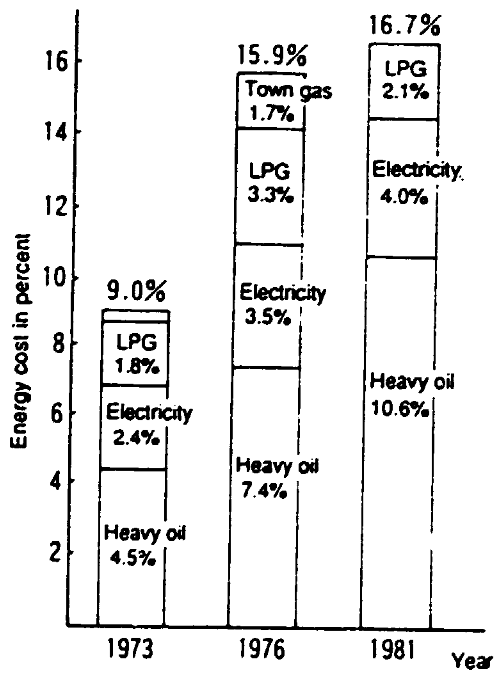


Figure 2 Energy cost distribution for total manufacturing cost

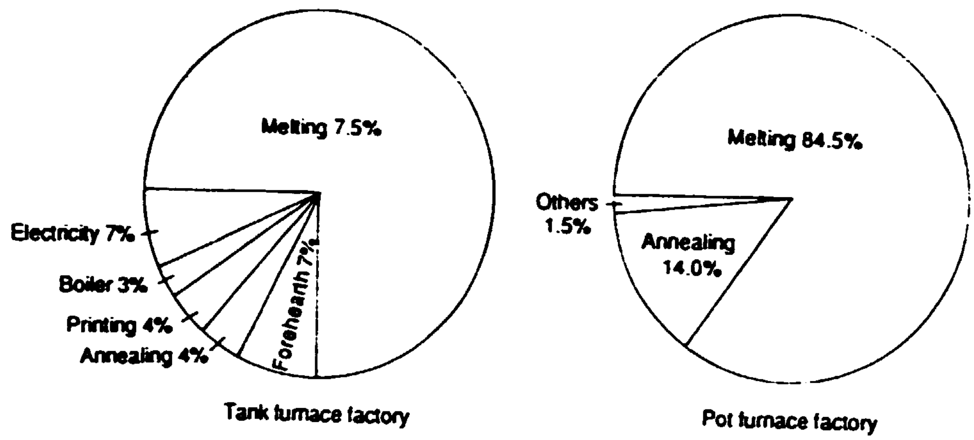


Figure 3 Share of total energy consumption

The situation differs according to the product types and scales; Figure 3 gives examples of the glass bottle manufacturing plant equipped with the tank furnace and the small-scale plant provided with the pot furnace.

The melting process is the greatest energy consumer in both the plant provided with the tank furnace for continuous production and the plant provided with the pot furnace for small quantity production of multiple product types.

The figure records 75% on the tank furnace; it even reaches close to 82% when 7% for forehearth is added. More energy, nearly 85%, is consumed in the case of the pot furnace.

Thus, when the energy conservation efforts are made, top priority must be placed on the furnace, then on the lehr.

The unit energy consumption means the energy required to make the product of unit amount (1 kg or 1 ton). It is expressed either by unit energy consumption if energy is used as the unit or by unit fuel consumption if the amount of fuel is used as the unit.

Batically, energy conservation in the glass factory is to reduce the unit energy consumption.

To reduce unit energy consumption, it is necessary to reduce the amount of fuels used, while it is important as well to increase production without increasing the amount of fuels, and to reduce the failure rate of production, thereby ensuring production increase in the final stage.

Specific energy consumption includes all the energy used to manufacture the product — oils such as heavy oil, LPG and kerosine oil, electric power used for transportation, etc.

Table 1 shows an example of energy consumption for each process and fuel in the glass bottle making plant. The management is required to get a total picture of this situation. Each process of the plant must grasp the unit fuel consumption or unit electricity consumption at each section.

Table 1 Distribution of energy consumption for glass bottle manufacture

$\times 10^{-4}$ kca/ton glass

	Heavy oil	Kerosene	LPG	City gas	Electricity	Total	%
Batch					1.47	1.47	0.58
Melter	161.80				16.96	178.76	71.03
Forehearth	1.77		14.76		0.8	19.33	6.89
Forming				0.08	26.85	26.93	10.70
Lehr			9.59		2.86	12.45	4.95
Printing, working			6.32	0.09	1.54	7.95	3.16
Package					0.47	0.47	0.19
Others	0.05	0.02	0.32	0.14	3.58	4.11	1.63
Total	163.61	0.02	30.99	0.31	56.74	251.68	
(%)	65.01	0.01	12.31	0.12	22.54		100

Regarding the furnace it is necessary to get correct data on the unit energy consumption (or unit fuel consumption). It corresponds to the energy consumption for the amount of glass taken out of the furnace. It may be expressed in calories or in the value converted into the amount of heavy oil. When the electric booster is used, the amount should include the electric energy used for that booster.

This applies also to the annealing furnace. In this case, the value is expressed in the amount of energy consumption for the amount of annealed glass.

Unit energy consumption varies greatly depending on the production scale. It also depends on the kinds of the glass, because it is related to the quality level. Figure 4 illustrates the differences in the tableware plant and the glass bottle plant. The smaller scale and the higher product quality level of the tableware manufacturing plant than those of the glass bottle making plant explain the reasons for considerably higher unit energy consmpion in the tableware manufacturing plant.

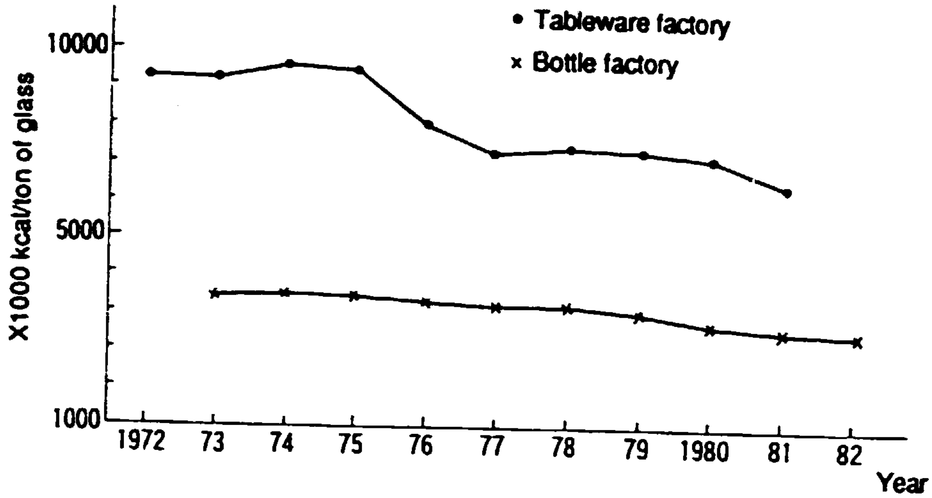


Figure 4 Unit energy consumption for factories

For the pot furnace factory of small quantity production of multiple product types, only the unit energy consumption in the furnace is clear; it is 4,000 to 8,000 kcal/kg. The difference depends on the kinds of the glass such as bolosilicate glass, soda lime glass and crystal glass, and furnace size.

Table 2 represents the situation of the unit consumption for the lehr. Big differences are observed according to heating method, operation time, heat of the glass to be loaded, amount of the glass loaded into the lehr processing capacity.

When the unit energy consumption is compared with that of other companies, it is necessary to note how the reference or standard has been determined as well as to clarify whether the energy means the total energy in the plant or only the energy used in the furnace, whether the forehearth is also included in the furnace or not, and whether electric power is included or not.

Table 2 Unit energy consumption of lehrs

Style	Fuel	Operat-ing time	Rising time Holding time	Production	Condition of input	Capacity	Unit energy consumption (monthly average)
Muffle	Gas	8h	4h	Cup	After forming	219 kg/h	448 kcal/kg
Direct	Electrity	8	4	Cup	After forming	219	385
Muffle	Gas	8	4	Cup	After grinding	156	1572
Muffle	Oil	8	16	Head lens	After forming	250	1861
Direct	Gas	8	2	Head lens	After forming	250	596
Muffle	Gas	24		Bottle	After forming	360	462
Direct Radiation	Gas	8	1	Grove lens	After forming	180	778
Muffle	Oil	24		Bottle	After forming	168	827
Radiant tube	Gas	8	1	Bottle	After forming	238	506

Figure 5 shows the flow sheet of energy conservation. The flow sheet should be modified according to the particular requirements of each plant.

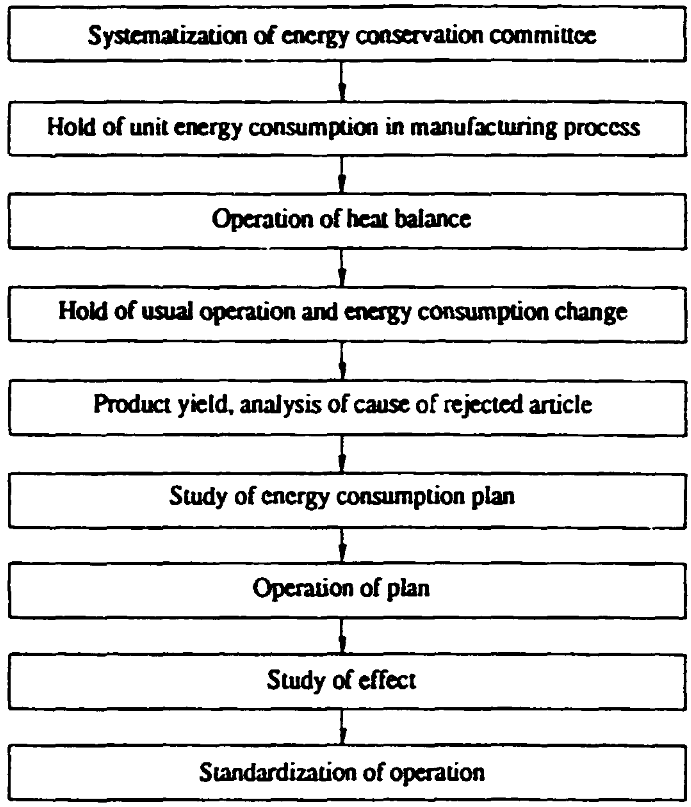


Figure 5 Flow sheet for energy conservation

3. Promotion of energy conservation technology

3.1 Melting furnace

Melting furnaces used in the glass production are available in a great number of types. They can be broadly classified into the types shown in Figures 6 to 10.

Figure 6 shows the side port type. This is a large furnace with a daily capacity of 100 to 150 tons or more. Two or more ports are installed in the direction at a right angle to the glass flow, and temperature distribution within the furnace can be changed to a desired value by controlling the amount of combustion of each port; this permits to produce the high-quality glass. This type of furnace is often used as a furnace for production of the plate glass or a bottle making large furnace.

Figure 7 shows the end port type furnace. It is a small and medium type furnace with a daily capacity of 100 tons or less. Compared with the side port type furnace, the end port type furnace features a simple structure and less expensive installation cost, but has difficulties in increasing its size. The flame returns along the longitudinal direction of the furnace and is sucked into the port on the side opposite to the rear wall. The temperature distribution inside the furnace varies according to the length of the flame and it is comparatively difficult to change the temperature distribution.

These two types of furnaces use in many cases the regenerators. Some of the small type furnaces use the recuperator.

Figures 8 to 10 illustrate the pot furnaces for small quantity production of multiple product types. Figure 8 illustrates the conventional multiple pot furnace used since early times, where six to ten pots are installed in the circular furnace, and glasses of different kinds are molten in these pots. The batch is loaded into the pot and molten during the night, and forming is performed during the daytime. The efficiency is not so good, and high-quality glass cannot be obtained. Most of the small and medium companies use this type of furnaces.

Figure 9 represents the pot furnace where only one pot is installed. It allows use of not only the close pot but also the open pot. In spite of its small size, it is designed for high efficiency. Some of this type furnaces have a unit energy consumption of 4,000 to 5,000 kcal/kg-glass.

Figure 10 shows a multiple pot furnace where the pots are installed in parallel, not in a circular form. The small and medium companies also tend to use robots and conveyers for transportation. Since the use of the circular form will make layout within the plant rather difficult, to solve this problem, this type of furnace has been developed.

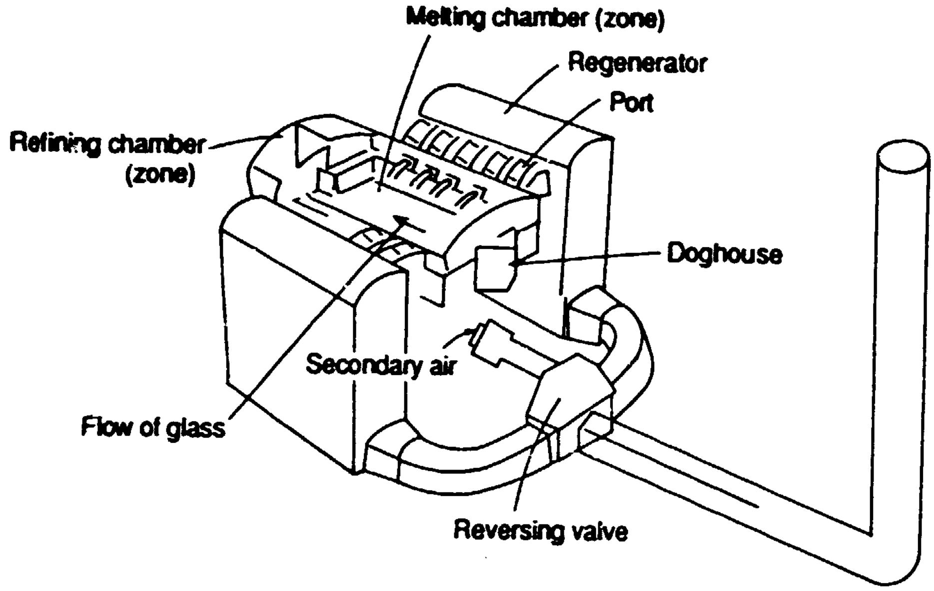


Figure 6 Tank furnace (Side port type)

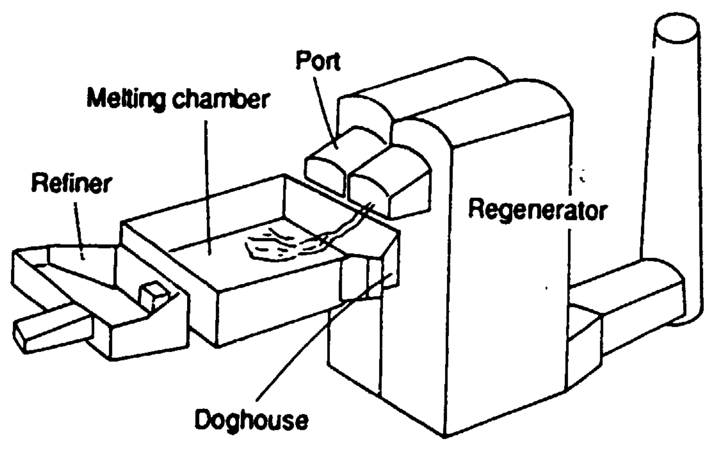


Figure 7 Tank furnace (End port type)

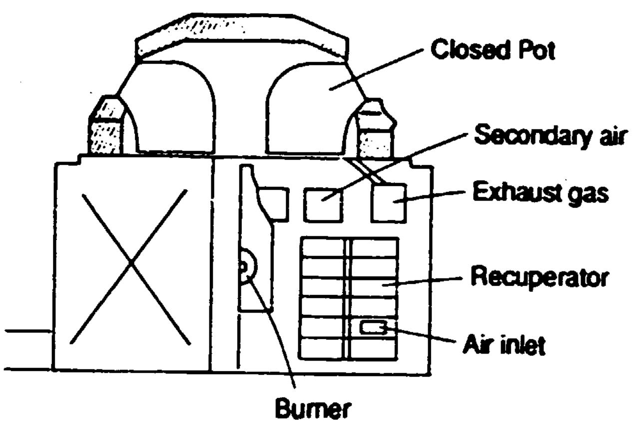


Figure 8 Pot furnace

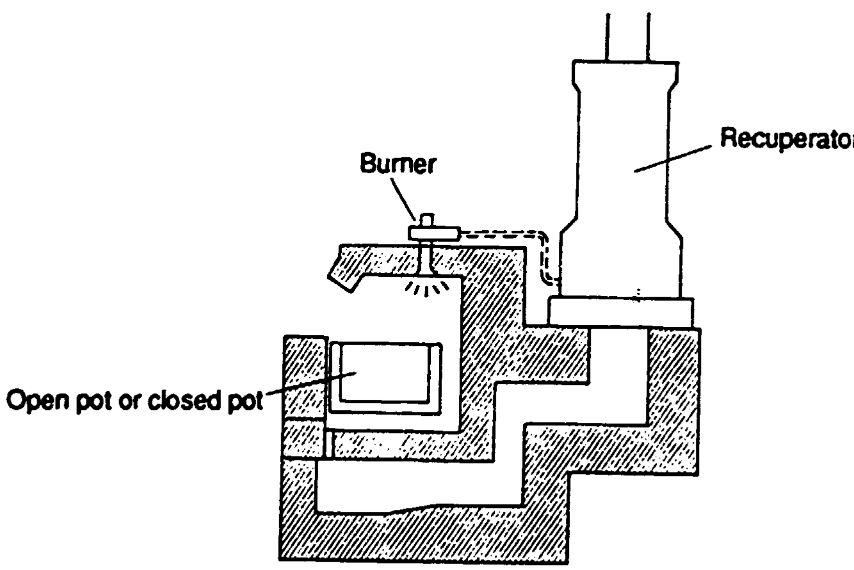


Figure 9 Single pot furnace (New type)

In the pot furnace the recuperator is used exclusively as a heat exchanger.

Since the melting furnace consumes much energy, this design provides a great energy conservation effect, which is represented in the reduced unit energy consumption. The unit consumption varies according to the scale. Figure 11 shows the yearly average value for the bottle making plant in Japan.

For twelve years from 1975 to 1986, unit energy consumption has reduced about 26% from 3,470,000 kcal/ton to 2,560,000 kcal/ton. According to the recent report, some of the furnaces have the unit energy consumption reduced below 2,000,000 kcal/ton. This is not only largely due to the reduced amount of oil used.

The first step toward the energy conservation in the melting furnace is to improve the combustion efficiency, to intensify heat insulation and to make an effective use of the exhaust gas.

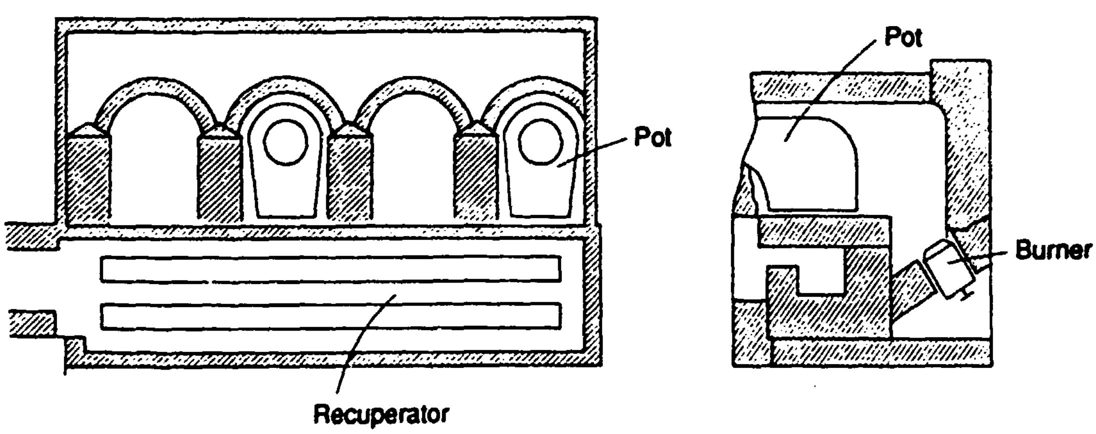


Figure 10 Parallel multi-pot furnace

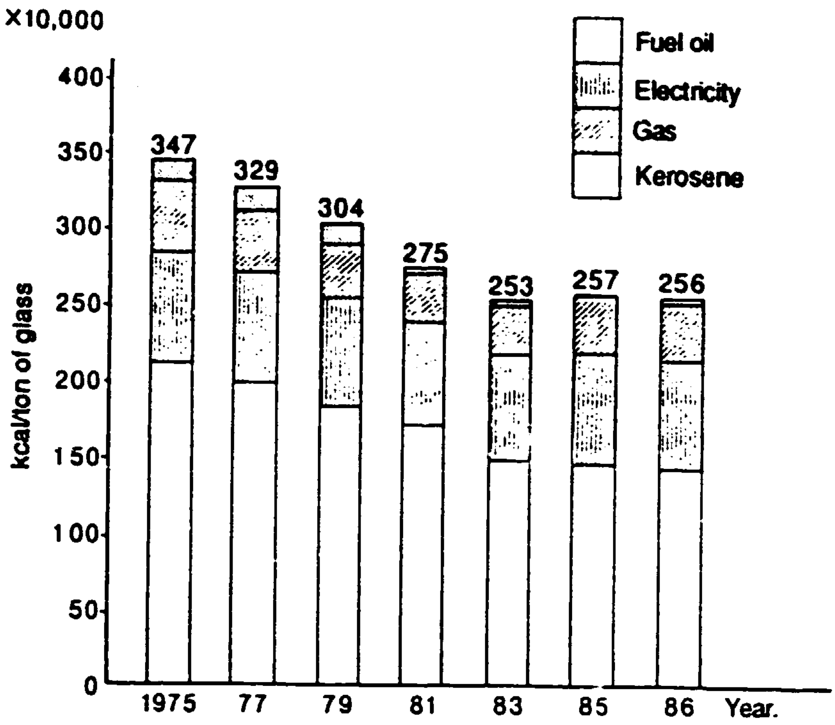


Figure 11 Unit energy consumption for glass bottle manufacturing

3.1.1 Combustion control

The fuel used in the melting furnace is liquid fuel (heavy oil) or gas fuel (LNG, LPG). Appropriate combustion can be checked by measuring the CO_2, O_2 and CO contained in the exhaust gas.

Glass materials used in the tank furnace are carbonates such as soda ash (Na_2CO_3) and limestone ($CaCO_3$). They are decomposed during the reaction for vitrification, to discharge CO_2. Thus, as a result of gas analysis, the sum of CO_2 generated by combustion and CO_2 generated from the material is produced in the tank furnace, so the amount of CO_2 is greater than that in the case of combustion alone. It is to be noted that when the combustion control is considered, the value will be inappropriate. It is desirable to make combustion control with oxygen volume in the exhaust gas for the tank furnace.

(1) Influence of cooled air other than preheated secondary air

The secondary air used for combustion is preheated by the heat exchanger. The primary air for spraying and air intruding from the clearance of the burner tiles enter the furnace as they are cold. Reduction in the volume of such cold air will lead to energy conservation. Figure 12 shows the result of calculating the amount of possible energy conservation by reducing the volume of this cool air and replacing it with the preheated air. It gives a graphic representation based on m=1.25 and the volume of cold air accounting for 10% of the entire air. If the cold air is reduced by 1% and the preheated air is increased by 1%, it corresponds to reduction of air ratio by 1%; the fuel is saved about 0.5%.

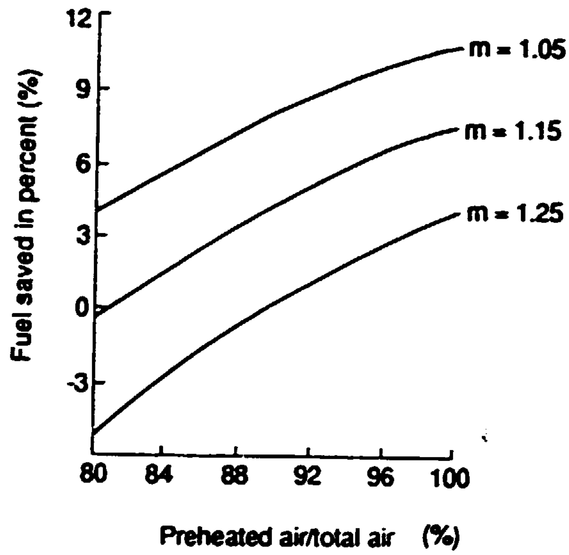


Figure 12 Relationship between preheated air and saving in fuel

(2) Temperature distribution inside the furnace

To ensure stable production of high-quality glass, temperature distribution must be maintained at the optimum level inside the furnace.

As shown in Figure 13, temperature distribution inside the tank furnace is so designed that the hot spot is located at the central position slightly displaced in the direction of the throat. The position of this hot spot moves a little depending on the load conditions.

If combustion is such that this spot is displaced greatly, the flow of the glass will be disturbed inside the furnace, and striae, blister, seed and similar defects will appear, deteriorating the product quality.

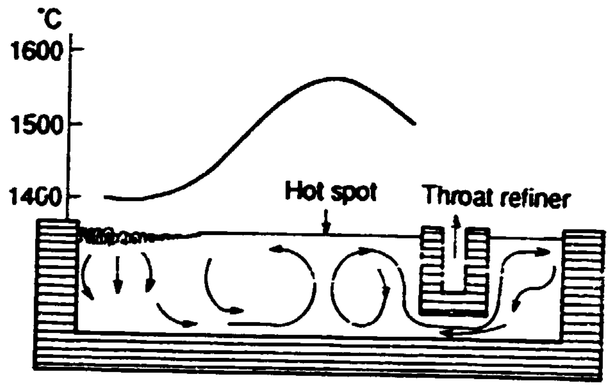


Figure 13 Relationship between temperature distribution and flow of molten glass

If the temperature distribution inside the furnace is maintained at the optimum value, the leading edge of the loaded batch will move in such a way that it is pushed backward. If the temperature distribution inside the furnace is not satisfactory, and the back current of the glass is poor, the batch will go forward.

In the side port furnace, temperature distribution should be optimized with comparative ease by controlling the combustion at each port, but it is actually accompanied by difficulties. That is, adjustment of the fuel for each port can be done by the burner, but the volume of the preheated secondary air cannot be controlled for each port. Figure 14 shows the volume of air supplied to each port. As shown in the figure, more gas flow occurs at the position closer to the flue through which the exhaust gas is discharged, and the checker bricks are also heated to high temperature. On the other hand, more air flows at the position farther from the flue. So great volume of air flows at the port farthest from the flue with large m combustion, whereas combustion with small "m" results at the port closest to the flue. The average value is recorded as a value for "m" in the analysis of gas inside the furnace. This cannot be said to be satisfactory either from the viewpoint of obtaining the optimum temperature distribution or from the viewpoint of energy conservation for combustion.

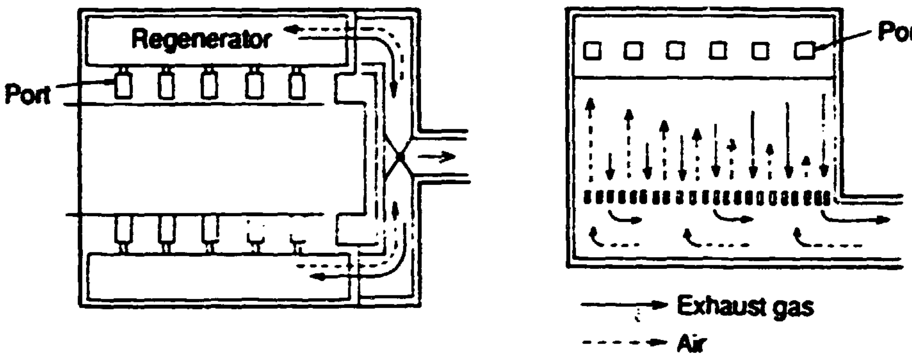


Figure 14 Distribution flow of exhaust gas and air in regenerator

To improve this situation, the separate regenerator chamber has been developed, which enables the volume of air to be controlled for each port. However, this is not much used because of the clogging caused by carry-over and other problems.

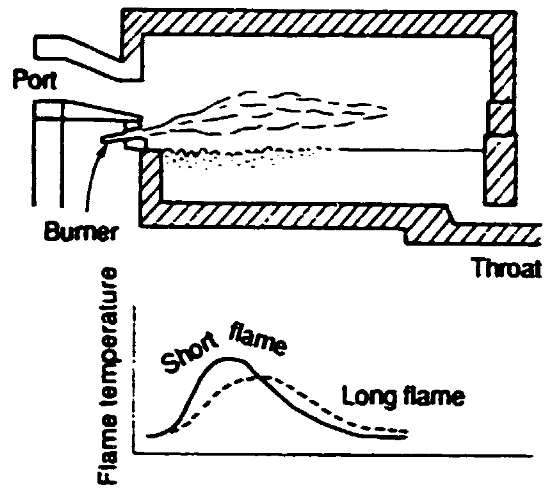


Figure 15 Temperature distribution of combination flame for end port type furnace

The optimum temperature distribution in the end port type furnace is more difficult to create than that of side port type. As shown in Figure 15, the burner of the end port type furnace is installed on one end of the glass flow, and there is no way of creating the temperature distribution except by controlling the flame length.
If the short flame is selected, the hot spot will be positioned closer to the burner; if the longer one is selected, it will move toward the throat side.

The flame length can be adjusted by:

(i) changing the burner capacity (by replacing the nozzle),
(ii) changing the burner type (by changing the volume of primary air and the flame rotary angle),
(iii) changing the burner atomizing pressure (longer flame is obtained by lowering the primary pressure), and
(iv) adjusting the secondary air.

However, these methods are also limited in effects, so the end port type is not often used for the large furnace with daily capacity of 100 to 150 tons or more.

(3) **Combustion in forehearth**

The forehearth has a function of controlling the glass temperature before formation, and has a direct influence on the quality of the glass product. Its outline is shown in Figure 16:

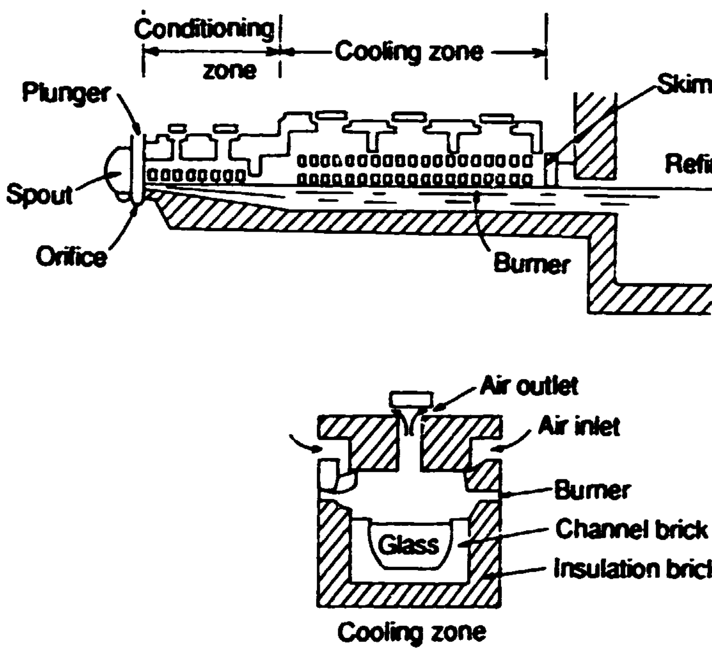


Figure 16 Outline sketch of forehearth

The basics for temperature control are:

(i) optimization of the temperature of the gob to be fed to the forming machine, and

(ii) temperature distribution from the forehearth inlet to the feeder to be adjusted so that the temperature will be lowered gradually along the glass flow, without any high temperature occurring on the way.

For this purpose, a great number of small burners are installed in the flow direction for temperature control. For this control the cooling zone is divided into 3 or 4 zones.

LPG or similar gas is used as fuel, because gas features fast combustion, easiness to create short flames, and little or no generation of carbon. When carbon falls on the glass, it will cause foams to be produced, resulting in coloration.

When the colored glass is molten, the color may be changed by the influence of the atmosphere. To ensure the stable coloring, sufficient care should be taken of the atmosphere for oxidation or reduction in the forehearth.

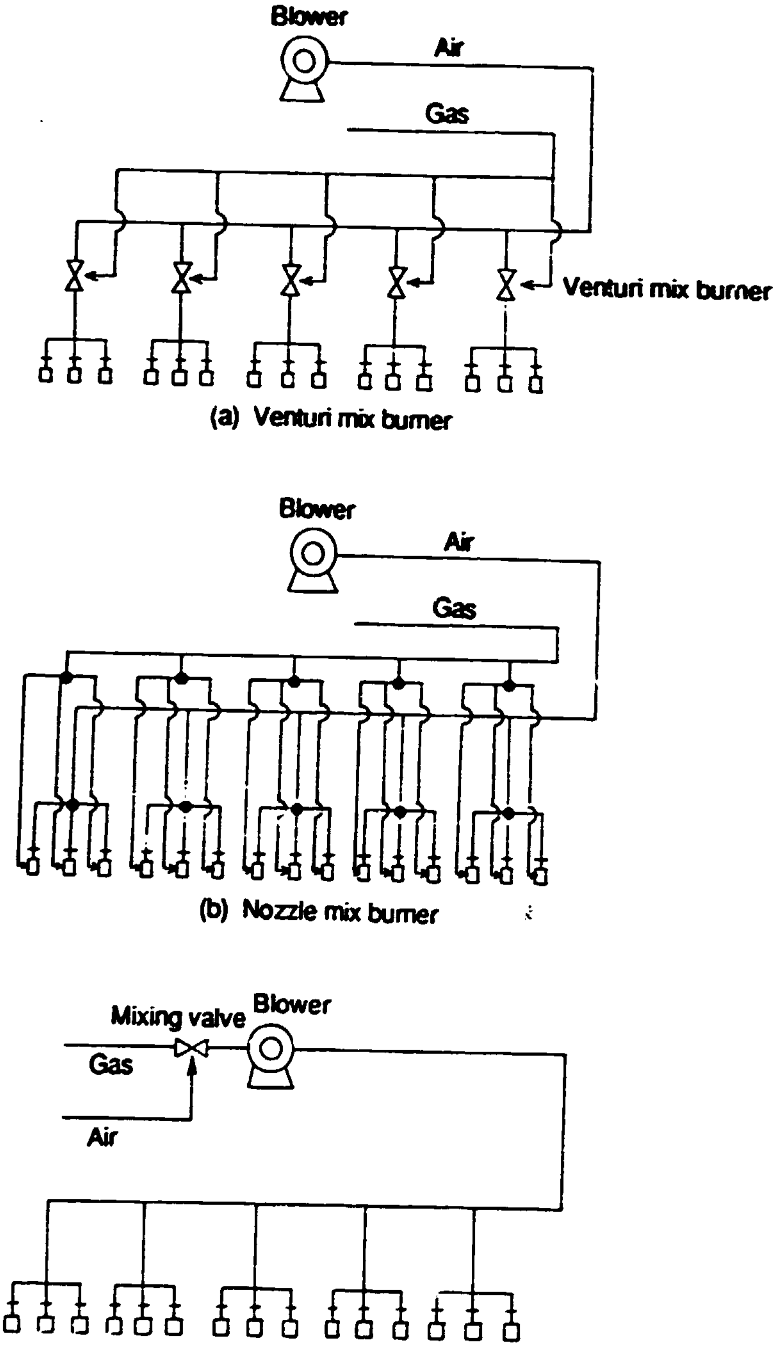
When gas is to be burnt, air is often pre-mixed into the gas. This method is available in three types as shown in Figure 17.

Figure 17 (a) represents a pre-mixing system using the venturi mixer for gas and air. This permits the total air ratio to be optimized, and, if the air ratio is changed in any zone, air ratios in other zones are also affected. So this is not applicable to the combustion control system where many burners are used.

Figure 17 (b) shows the method where gas and air are mixed by the burner tip. This method is designed to ensure safety by preventing back firing, but it fails to eliminate interference between gas and air zones.

Figure 17 (c) illustrates the method where the gas-air pre-mixing valve is installed in front of the blower. According to this method, the gas-air ratio is constant in front of the blower, so the air ratio is constant at all zones, even if the volume to be combusted by the burner is changed for each zone. Therefore, it ensures reliable control of the air ratio, and permits substantial energy conservation, according to a report.

Comparison of oxygen (O_2) in the exhaust gas according to three methods has revealed that 8% of oxygen was contained in the exhaust gas according to method (a), 6% according to method (b), and 1% according to method (c). Substantial reduction of the air ratio has succeeded in reducing the volume of the fuel gas.



(a) Venturi mix burner

(b) Nozzle mix burner

(c) Pre-mix burner

Figure 17 Gas burner system

3.1.2 Insulation

Since the melting furnace has a large surface area, minimization of loss of heat from the furnace wall is a major concern for energy conservation.

However, the heat insulation of the melting furnace must be carefully studied. Otherwise, it will cause erosion of the used bricks, reduce the service life of the furnace and deteriorate the glass quality, thereby bringing about many adverse effects.

(1) Insulation for melting chamber bottom

Improved insulation at the bottom will raise the furnace bottom ground temperature. This will improve the melting capacity of the furnace, resulting in better yield. Subsidiary advantage of productivity improvement is secured in addition to the direct advantage of reduction of the heat loss from the bottom. Figure 18 (a) illustrates an example of insulation. Compared with the conventional case without using the insulation brick, the amount of heat loss has reduced by about 43% from 3240 to 1382 kcal/m²h.

The refining chamber is also heat-insulated as the melting chamber. The insulation may be intensified in order to prevent the glass from being cooled.

(2) Crown insulation

As silica brick used for the crown, super-duty silica bricks have been developed; they are high-purity products containing the minimum alkali and alumina, providing improved insulation.

Some furnaces use AZS type electrofused refractory (fused AZS) for the crown. Figure 18 (c) shows the example of insulation. AZS means alumia-zirconia-silica.

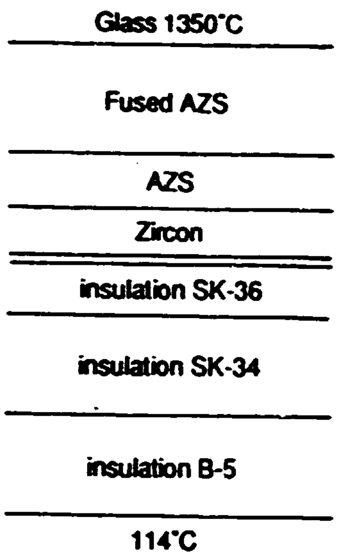
When the temperature inside the furnace is 1500°C, the temperature on the outermost insulation wall is reduced to 95°C, and the amount of heat loss reaches 810 kcal/m²h. When insulation is not provided, the crown external wall temperature reaches 300 to 400°C.

(3) **Side wall insulation**

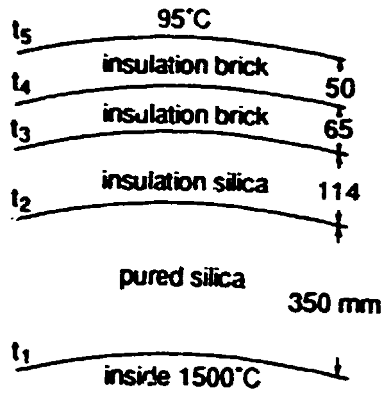
It has been an established trend that the fused AZS is used for the tank block, and the insulation is provided, except for the metal line. The brick joints are also insulated but sufficient care is required. Figure 18 (c) shows an example of insulation, where the outermost wall uses the ceramic fiber board. When the average temperature on the inner wall is 1350°C, the outer wall temperature is 141°C, and the amount of heat loss is 2017 kcal/ m^2h. The temperature of the outer wall is 232°C, and the amount of heat loss is 6102 kcal/ m^2h, if insulation is not provided.

The upper side wall not in contact with the molten glass has come to use the fused AZS in place of the silica brick. At the same time, insulation is also improved. Figure 18 (d) shows an example of insulation:

When the average temperature on the inner wall is 1500°C, the outer wall has the temperature of 171°C, and the amount of heat loss of 2088 kcal/m^2h. When insulation is not provided, the temperature on the outer wall reaches 304°C and the amount of heat loss reaches 6152 kcal/m^2h.

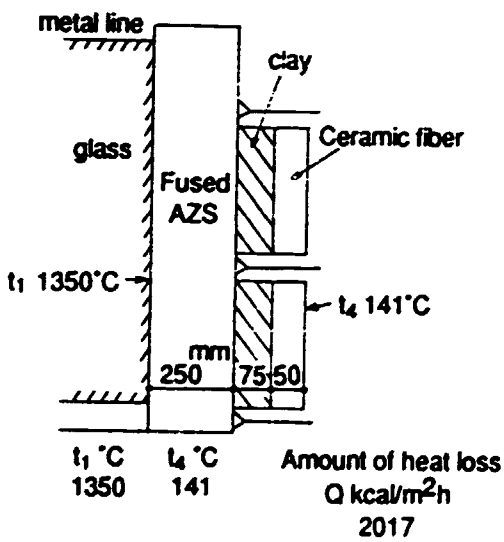


(a) Melting chamber bottom

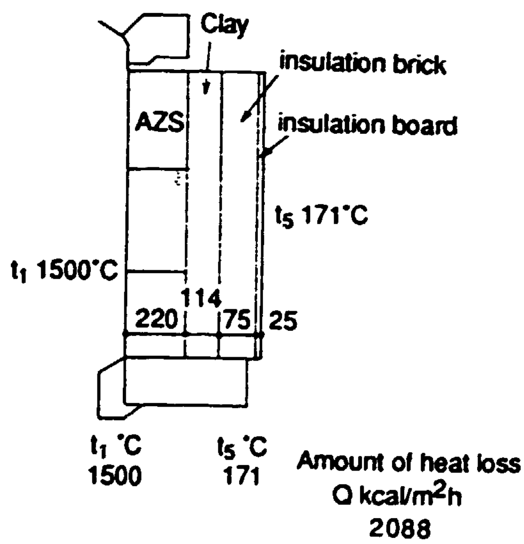


t_1 °C	t_2 °C	t_3 °C	t_4 °C	t_5 °C	Q kcal/m²h
1500	1343	1079	769	95	810
1600	1432	1150	820	100	865

(b) Melting chamber crown



(c) Melting chamber tank block



(d) Melting chamber side wall

Figure 18

3.1.3 Exhaust heat recovery

Melting of the glass requires the temperature of 1450 to 1550°C, so the exhaust gas contains a great deal of heat. The temperature of the exhaust gas entering the regenerator from the melting chamber reaches as high as 1450°C. In this way, exhaust gas having a high temperature is recovered by the regenerator or recuperator, and is used to preheat the secondary air for combustion.

(1) Exhaust gas recovery by regenerator

The regenerator is so designed that high temperature exhaust gas is passed through the checker bricks, and the heat is absorbed by these bricks. After the combustion gas is fed for some time (15 to 30 minutes), air is fed there by switching, and brick heat is absorbed, raising the air temperature. The air is used for combustion. This procedure is repeated at intervals of 15 to 30 minutes. Thus, two regenerators are required for each furnace.

The exhaust gas temperature is 1350 to 1450°C at the regenerator inlet, and drops 400 to 500°C at the regenerator outlet. Air enters the regenerator at the room temperature, and is heated to reach 1200 to 1300°C at the outlet. Then it is used as secondary air for combustion.

(2) Exhaust gas recovery by recuperator

Exhaust gas and air flow through the wall of the recuperator, and the heat is exchanged by the wall. This method is used for the small or medium furnace where the amount of exhaust gas is smaller, and is featured by its capacity of ensuring the stable pre-heating air temperature. However, the maximum temperature of the pre-heated air does not reach that in the case of regenerator.

The air leakage through the wall into exhaust gas side occurs in the brickwork type recuperator. To check if leakage has occurred to the recuperator is to analyze the exhaust gas to examine the change in oxygen. If air has entered the exhaust gas by leakage, the gas temperature will drop and the increased amount of exhaust gas will cause a greater loss of the exhaust gas. If air leaks into the exhaust gas through the secondary air passage, the amount of the secondary air will become insufficient in an extreme case, resulting in combustion failure.

Table 3 shows the leakage of the recuperator used in the pot furnace:

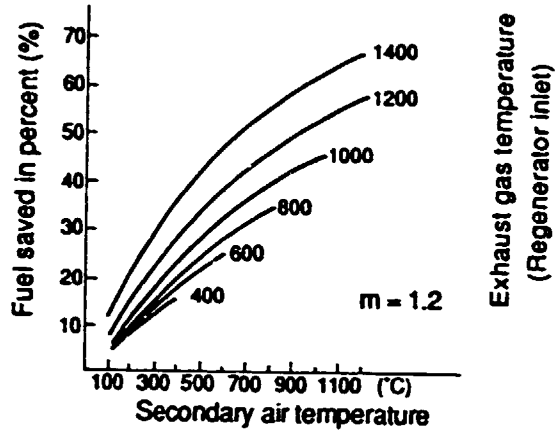
Table 3 Air ratio of exhaust gas for pot furnace and recuperator

	A	B	C	D
Furnace outlet O_2%	0.2	3.3	1.0	0.6
Air ratio (m)	1.01	1.17	1.05	1.02
Recuperator outlet O_2%	6.2	11.8	5.6	8.9
Air ratio (m)	1.4	2.2	1.3	1.7

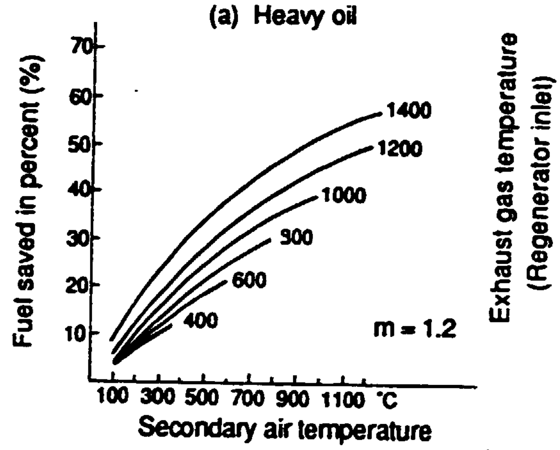
Regarding 4 furnaces, the content of the oxygen (O_2) was analyzed in the exhaust gas inside the furnace and at the recuperator outlet, and the air ratio (m) was compared. The value "m" was 1.05 to 1.3 in the furnace C where the difference was the minimum, and 1.17 to 2.2 in the furnace B where the difference was the greatest, showing an increase of about 1.8 times. As can be seen, entry of air is unavoidable for the recuperator, and this trend becomes more conspicuous as the furnace becomes older. So daily care is essential.

Figures 19 (a), (b) and (c) show relationship between the percentage of conserving the fuel and the preheated air temperature when the exhaust gas is used to preheat the secondary air. Figure 19 (a) shows the example in the case of heavy oil. When the temperature at the regenerator inlet is 1200°C, the fuel of about 50% will be saved if the air temperature is pre-heated to 900°C. If the air temperature is raised to 600°C when the exhaust gas temperature is 800°C, the fuel of about 28% can be saved. In this way, the furnace with higher exhaust gas features the better effect of air pre-heating, according to this Figure.

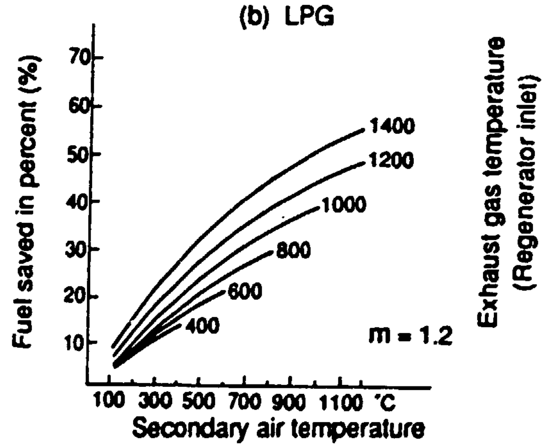
Figure 19 (b) illustrates the situation with LPG, while Figure 19 (c) represents the situation with LNG.



(a) Heavy oil



(b) LPG



(c) LNG

Figure 19 Savings in fuel due to preheated air

3.2 Lehr

Annealing is a process specific to glass manufacturing. If the glass is left as it is after having been formed, strain will occur due to the temperature differences on the surface and interior, and ·-ill break when it has exceeded a certain amount. Annealing is performed to minimize the possibility of strains occurring during the cooling process. To rationalize the cooling process, it is essential to get correct information on why stain occurs to the glass.

Lehr is available in two types; a direct fired type where combustion gas contacts the product directly, and a muffle type where gas and products are separated from each other by the partition. The muffle type permits use of less expensive heavy oil but the heat efficiency is low.

The direct fired type uses gas and electricity as fuels, and features high heat efficiency and easy temperature control. So the direct fired type is coming to be used in greater numbers.

Figure 20 illustrates an example of the lehr based on the forced circulation convection system. Gas inside the furnace is force-circulated by the fan to ensure uniform temperature distribution, improving heat transfer efficiency. It permits annealing in a shorter time than the conventional Lehr.

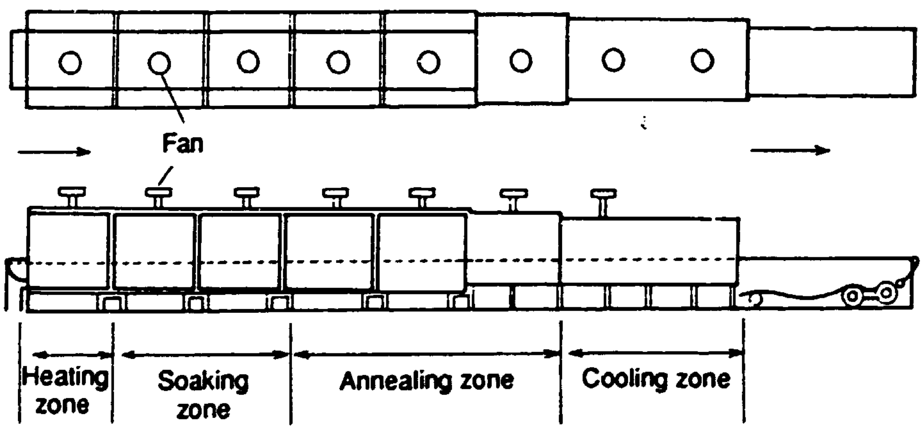


Figure 20 Outline sketch for lehr

Energy conservation of the lehr should be carried out, with consideration given to the following:

(1) Heat insulation of the furnace wall

The conventional wall materials were mainly the refractory bricks and insulating bricks. For the furnace wall, it is effective to directly use the heat insulating materials made of fibers having the minimum thermal capacity, when the temperature is as low as 600°C as in the lehr and the operation may have to be stopped during the night. Since the furnace having the minimum thermal capacity is susceptible to temperature variation, sufficient consideration must be given to the control system. As the products with considerably high temperature are charged into the lehr, the amount of fuels for heating can be reduced by providing sufficient insulation.

(2) Preventing cold air from entering through the inlet opening

The lehr has a short distance between the inlet and the heating zone, and soaking zone is quite close to the inlet. Therefore, entry of cold air from the inlet will give a serious influence; for example, it will disturb the temperature distribution inside the furnace. Since the opening serves as an inlet for the products, it is designed to be wide open. It will be necessary to install a damper or insulating curtains, without keeping it open. This opening also serves to discharge the heat of high temperature from the soaking zone.

(3) Preventing the outlet opening from being opened

As the inner part of the lehr outlet has higher temperature, air flows toward the inner part. Air entering the outlet will disturb the temperature distribution in both the vertical and horizontal directions inside the furnace. It is desirable to provide covers above the belt conveyor as well as below it to enclose the space whenever possible.

(4) Alleviating the mesh belt heating

The mesh belt is made of steel wire or stainless steel. When it enters the furnace and is heated, the calorie will be considerably high. For example, assume the following:

Weight of products to be processed: 630 kg/h

Temperature of the product entering the lehr: 400°C

Soaking temperature: 550°C

Specific heat: 0.252

Then, the calorie required to heat the product is given by:

$Q_1 = 0.252 \times (550 - 440) \times 630 = 23814$ kcal/h

where:

Belt width: 1500 mm
Belt weight: 20 kg/m²
Belt speed: 380 mm/min.
Temperature of product entering the lehr: 15°C
Soaking temperature: 550°C
Specific heat: 0.132

The calorie required for belt heating is given by:

$Q_2 = 0.132 \times (550 - 15) \times 20 \times 0.38 \times 1.5 \times 60 = 48304$ kcal/h

The calorie required to heat the belt is more than twice that required to heat the product. To save this heat, the belt wire diameter is minimized, and the weight is reduced by making the pitch loose. However, this method has a defect in reducing the strength. The returning belt passes outside the furnace. To prevent the temperature from lowering to the room temperature, some plants provide improvements so that the belt will pass through the bottom inside the furnace, and the heated belt will enter the heating zone.

(5) **Making the temperature inside the lehr uniform**

The Lehr interior is designed so as to have a certain temperature curve with respect to the flow, but the temperature distribution in vertical and horizontal directions with respect to the flow cannot be controlled. If this temperature distribution is not uniform, the strain may be removed differently depending on the position on the belt conveyor. This will give an adverse effect on the production yield. To improve the temperature distribution, the forced circulation convection system is used, as illustrated in Figure 20.

(6) Temperature of the product entering the lehr

After being formed, the product is carried by the conveyor and is charged into the lehr. The product temperature differs depending on the distance to be carried by the conveyor. When energy conservation is considered, the product should enter the lehr after being carried over the minimum possible distance. This is related to the total layout of all the production processes, so modification is not very simple. However, if layout modification is possible in future, the possibility of this improvement should be studied.

3.3 Heat balance (in melting furnace and lehr)

Measuring the furnace temperature or observing the combustion is the routine procedure to ensure stable furnace operation and high-quality products. Heat balance is an effective means of promoting energy conservation. Heat balance table is made to numerically grasp the present situation of heat loss and efficiency in furnace operation.

For the concrete heat balancing technique and calculation formula, see the related publications. The following shows major points for measurements in heat balancing procedure:

(1) Heat input

Combustion heat of the fuel: lower calorific value of the fuel

Sensible heat of the fuel: This may be omitted when fuel is not preheated.

Sensible heat of air for combustion: Calorie of the air preheated by the regenerator, etc. The flow rate is calculated from the inlet area and air flow rate.

Batch sensible heat: This is omitted except when it is not preheated.

(2) Heat output

Heat carried out by glass: It is a common practice to take heat balance including that of the refiner. The glass temperature in this case is measured at the forehearth inlet. The amount of the glass should be the amount taken out of the forming machine, or the amount of loaded batch. Table 4 illustrates the calorie of the glass:

Table 4 Heat required for production of various kinds of glass at various temperatures (Theoretical value)

Kinds of glass	Temperature °C	Heat required for melting glass kcal/kg glass					
		Cullet addition rate (%)					
		0	20	40	60	80	100
Tableware glass	1400	576	543	510	477	444	411
	1250	530	497	464	431	398	365
Sheet glass	1400	666	615	563	512	460	409
	1150	571	520	468	417	365	314
Borosilicate glass	1400	508	482	455	429	402	376
	1300	477	451	424	398	371	345
Lead crystal glass	1400	496	472	448	424	400	376
	1100	391	367	343	319	295	271

Heat loss from furnace wall: The heat loss of the crown, side wall, bottom, etc. are measured by the heat flow meter. One or more points for 5 m^2 must be measured. When the heat flow meter is not available, use the surface thermometer to measure the surface temperature, and obtain the answer by calculation. It should be noted that calculation assumes the air flow close to the furnace wall as natural convection.

Latent heat of vaporation for batch moisture: For measurement, sample the batch moisture from the hopper located in front of the furnace.

When the batch charger and throat are cooled, add them to the amount of heat loss. Furthermore, if the electric booster is used for auxiliary heating, it is necessary to add its heat input and heat output.

Example of heat balance chart for glass melting tank is shown in Figure 21.

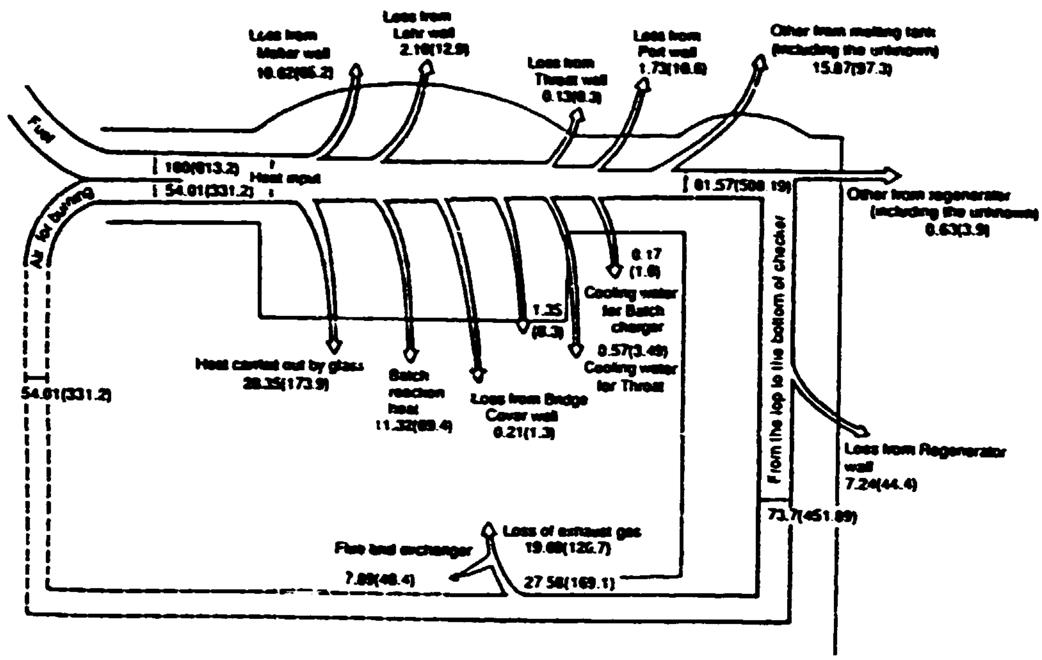


Figure 21 Heat Balance Chart for Glass Melting Tank

Tables 5 to 8 show the examples of the heat balance of the furnace, forehearth and lehr. Table 5 indicates the heat balance for three furnaces produced at different times. It shows that good results are obtained according to the progress of the energy conservation efforts. Tables 6 and 7 show the heat balance of the forehearth. The positions for measuring the temperature is illustrated in Figure 22.

Table 8 presents an example of the lehr heat balance. The characteristic of this case is that the other heat outputs are greater. Amount of calorie to heat the chain belt appears to be included.

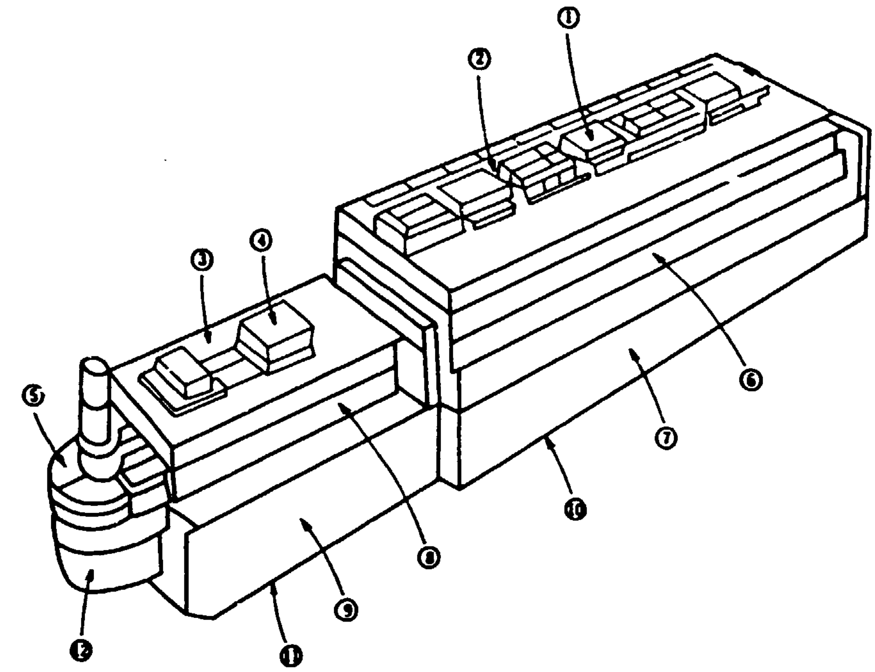


Figure 22 Measured positions for heat loss measurement from forehearth

Table 5 Heat balance of three generation furnaces

		A After 1972	B	C
Pull	(t/day)	266	121	264
	(fx^2/t)	4.25	5.58	5.53
	$(10^4$ kcal/t)	132.3	121.5	110.7
Heat loss	(kcal/m²h)	1666.1	1223.2	677.5
	$\times 10^4$ kcal/t.d	25.6	26.8	13.5
Heat efficiency %		34.1	39.7	44.0
Heat carried out by glass (%)		27.4	28.4	31.4
Reactor heat by batch (%)		67	11.3	12.6
		(Cullet 38%)	(Cullet 23%)	(Curret 16%)

		A	B	C
Heat input	Fuel	100	100	100
	Secondary air	50.7	54.0	56.6
Heat output (%)	Melter wall	12.0	10.82	5.8
	Refiner wall	2.0	2.1	0.8
	Port wall	1.7	1.7	1.4
	Throat wall	0.1	0.13	0.1
	Batch moisture	2.3	1.35	2.50
	Loss by water cooling for throat	0.2	0.57	0.33
	Loss by water cooling for batch charger	0.2	0.17	0
	Others	21.1	15.9	27.0
	Heat carried out by glass	27.4 ⎤ 34.1	28.4 ⎤ 40.0	31.4 ⎤ 44.0
	Reactor heat of batch	6.7 ⎦	11.3 ⎦	12.6 ⎦
	Total	73.7	72.4	81.9
	Regenerator heat loss wall	3.6	7.2	3.7
	other	5.4	0.63	0.5
	Total	9.0	7.9	4.2
	Heat loss by exhaust glass	17.3	19.7	13.9

Table 6 Heat loss value of forehearth

		A Area m²	B Average heat loss kcal/m²h	A × B kcal/h	Total heat loss kcal/d	Part loss/ total loss %	Heat loss/ area kcal/m²h
Crown	1	0.56	10000	5600			
	2	7.30	519	3788			
	3	1.80	885	1593	372000	37.3	1526
	4	0.11	9000	990			
	5	0.39	9050	3530			
Side wall	6	7.48	1206	9017			
	7	7.84	751	5886	411000	41.2	959
	8	1.0	1290	1290			
	9	1.90	490	931			
Bottom	10	8.43	695	5860			
	11	2.05	387	793	214000	21.4	768
	12	1.11	2030	2253			
Total		39.97		41531			

Table 7 Heat balance of forehearth

		× 10⁴ kcal/d	%	as 100% heat bring of glass
Input	Heat bring of glass	2184.5	83.0	100
	Heat of combustion	448.8	17.0	20.5
			100	120.5
Output	Heat carried out by glass	2104.6	79.9	96.3
	Heat loss from wall	99.7	3.8	4.6
	Exhaut gas and other	42.9	16.3	19.6
		2633.3	100	120.5

Table 8 Heat balance of lehr

Heat input			Heat output		
	kcal/kg	%		kcal/kg	%
Fuel	450	79.5	Side wall heat loss	27.4	4.8
Heat carried in by glass	116.3	20.5	Open space heat loww	139.1	24.5
			Exhaust gass heat loss	134.0	23.7
			Heat carried out by glass	14.0	2.5
			Other	251.8	44.5
Total	566.3	100		566.3	100

3.4 Other measures

(1) Use of electric booster

To increase the pull without changing the furnace size, alternating current (AC) is supplied to the melting chamber or heating. This method is often used for the bottle making furnace. Since this electricity is used for glass melting at the efficiency of close to 100%, this method is very effective.

Since, the electricity required to increase the pull by 1 ton is said to be 22 to 28 kW. Assuming it to be 28 kW, input of 24080 kcal is sufficient since 1 kW corresponds to 860 kcal. Use of the booster to increase the pull will reduce the specific energy consumption.

(2) Bubbling

Air is put through the bottom of the melting chamber, and glass is agitated by the bubble, thereby speeding up the homogenization and improving the product quality. Bubbling increases the temperature at the bottom of the melting chamber, resulting in increased furnace temperature. Thus, this method directly contributes to energy conservation. Moreover, improved product quality reduces the failure rate, and decreases the specific energy consumption.

The bubbling method

Several nozzles or tens or more nozzles are installed, perpendicular to the flow of the glass, at the bottom close to the hot spot of the melting chamber, and 1 to 10 liters of air per hour is fed into molten glass.

(3) Electric heating of forehearth

It is extensively known that direct heating of the forehearth by electric power will greatly save energy. In the case of borosilicate glass, the entire forehearth is enclosed without contact surface between air and glass; this method ensures high-quality glass. Since this method, however, is not often used, its advantages or disadvantages are not so clear at present.

(4) Use of cullet

Figure 23 illustrates that use of a great number of cullet saves energy. When no cullet is used at all in the furnace with a daily production capacity of 150 tons, fuels of 200 kg/kg-glass are used. On the other hand, when 50% of cullet are used, spent fuels will be reduced to about 180 kg/kg-glass.

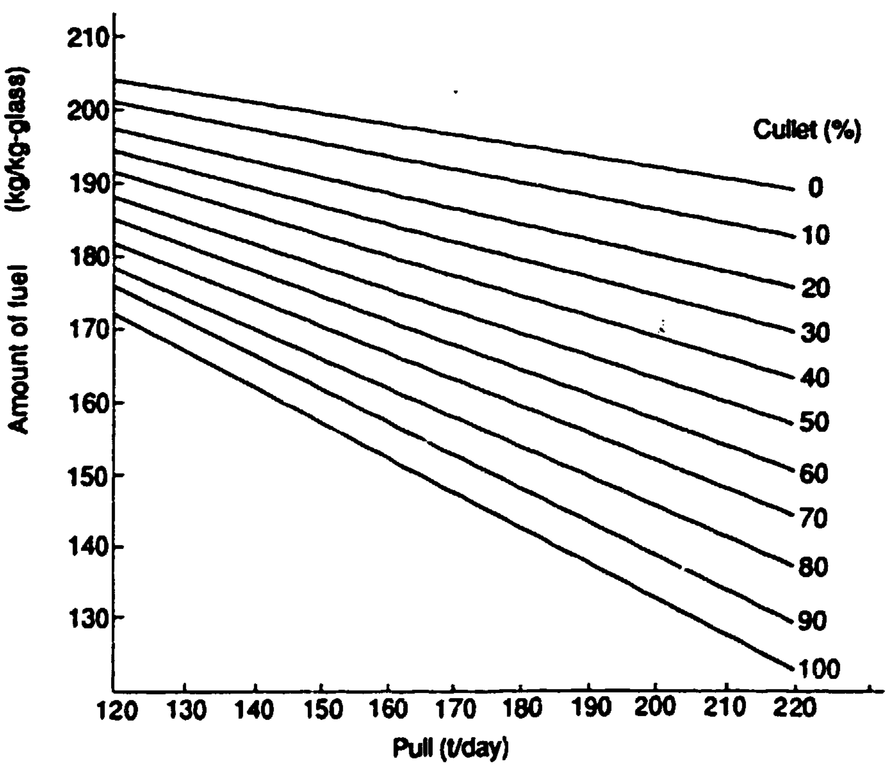


Figure 23 Relationship between pull anf fuel amount for various cullet content

Use of only the cullets produced in the plant may be satisfactory. However, generation of such a great deal of cullet means a high failure rate in production; this is not desirable. Cullet placed on the market are inevitably mixed with foreign substances, and it is expensive to maintain the quality. If high-quality cullets can be ensured in ground amount, use of many cullet will contribute to energy conservation.

(5) **Development of low melting temperature batch**

Various studies have been made on the batch for reducing melting temperature without deteriorating the quality of the glass. The method considered to be most effective is to add lithium. Lithium carbonate or spodumene (Li_2O, Al_2O_3 $4SiU_2$) is used as lithium materials. The spodumene is composed of 5% of Li_2O, 18.7% of Al_2O_3, 74.7% of SiO_2 and 0.1% of Fe_2O_3. They must be checked for confirmation before use.

Addition of a small amount of lithium reduces the high temperature viscosity of the glass, and reduces the foam breaking temperature. Take an example of the glass (composed of Na_2O-CaO-SiO_2). As illustrated in Figure 24, the temperature showing $\log \eta = 2.0$ was 1400°C when 0% of Li_2O was used. When 0.2% of Li_2O is used, that temperature is reduced by 30°C. When 1.9% of Li_2O is used, that temperature is reduced by 60°C to 1340°C. Thus, addition of a small amount of lithium reduces the viscosity. This has been demonstrated by the reduced bubble breaking time in the commercial furnace. However, the lithium material is expensive. So study will be made according to the trade-off between the energy conservation and material cost.

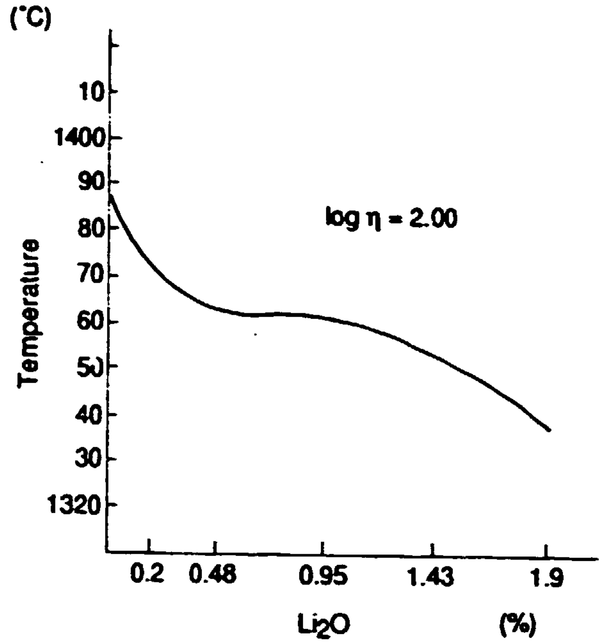


Figure 24 Viscosity vs Li_2O content

(6) Furthermore, for the small furnace with a daily production capacity of 10 tons or less, conversion to the fully electric furnace, addition of oxygen in the burner combustion and introduction of gas into the primary air atomizer must be studied, but they will not be described in this paper.