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UNITED NATIONS

INDUSTRIAL DEVELOPMENT ORGANIZATION

THE FINAL REPORT

ON

PROGRAMME FOR RATIONAL USE OF ENERGY SAVING TECHNOLOGIES

IN

RUBBER AND IRON CASTING INDUSTRIES

IN

CHINA AND VIETNAM

UNIDO Contract : 97/080

Project No : US/RAS/95/048

The Energy Conservation Center, Japan

CONTENTS

1. Preface

Excessive use of energy is one of the characteristics of many industrial plants in developing countries. This pattern of energy utilization is not sustainable. Therefore, it is imperative to introduce and disseminate information on modern energy conservation measures and technologies among the parties concerned in government and especially, at the plant level. To fulfil these goals, UNIDO, with financial support from the Government of Japan, has been sponsoring a programme designed to increase awareness and knowledge of government officials and industrial users on rational use of energy saving technologies in developing countries.

In order to achieve the objectives of this programme, UNODO has adopted the following strategy.

1. Conduct plant surveys to assess the existing technologies and operational practices, and to identify the necessary energy saving measures.

2. Prepare Handy Manuals on appropriate energy management and energy saving techniques and technologies.

3. Organize seminars to be attended by government officials, representatives of industries and plant managers, engineers and operators to:

    - present and discuss the content of the manuals, and
    - report on plant assessments and make recommendations for improvements.

4. Disseminate the manuals locally and to other developing countries.

The activities under the programme are carried out jointly by UNIDO and the Energy Conservation Center (ECC) of Japan, a subcontractor to UNIDO.

In 1997, the fifth project under this programme was implemented in Chaina and Vietnam, targeting two energy intensive industrial sectors, Rubber and Iron casting industries. This final report presents the output of the project.

2. Project Outline

The project goal was to increase awareness and knowledge among the concerned parties on rational use of energy saving technologies in rubber and iron casting industries. The implementation strategy included the preparation on Handy Manuals on the targeted industries and the organization of seminars to facilitate information transfer. The project activities were conducted in the following chronological order:

March 1997

Assignment of two Japanese experts in rubber and iron casting industries

September to October 1997

Field survey on rubber and iron casting industries in China and Vietnam

November to December 1997

Preparation of the draft Handy Manuals on rubber and iron casting industries by the experts (Japan)

December 1997

Submission of three copies of the draft Handy Manuals to UNIDO for review and approval.

February 1998

Holding of seminars in China and Vietnam to present and discuss contents of the manuals and the findings of the field surveys.

January 1999

Delivery of 600 copies of the finalized Handy Manuals to UNIDO

3. Evaluation of the seminars

In this section, an attempt is made to evaluate the seminars on the use of energy saving technologies in rubber and iron casting industries in China and Vietnam, sponsored by the United Nations Industrial Development Organization (UNIDO) and the Ministry of International Trade and Industry (MITI), Japan, and organized by the Energy Conservation Center (ECC), Japan. The seminars were hosted by the Ministry of Industry of Socialist Republic of Vietnam and by the State Economic & Trading Commission of People's Republic of China. The first seminar was held on 12-13 February 1998, in Beijing and the second on 25-26 February 1998 in Hanoi. About 40 participant in Beijing and 70 in Hanoi from government agencies and private companies attended to the seminars respectively.

3.1 Energy situation in China

In China, coal account for 62% of energy supply, oil for 14%, natural gas for 1% and renewable & waste for 19%. Coal production was 680 million tons in 1995, and is expected to reach 790 million tons by the year 2000. From 1973 to 1985, crude oil resources were developed mildly and oil production increased steadily. Since 1986, oil production has increased rather rapidly about two times higher till 1995. Natural gas production and consumption are in very low level. In 1995 consumption of commercial energy is in industry 70%, residencial/commercial 16% and transportation 9%. From 1995 to 2000, commercial energy consumption is expected to increase more than 20%, and in industry the ratio is still kept 70%. In recent years China changed to be a country of oil import and further to be a very big energy consumption because of rapid economic development.

China made up the energy conservation law at the end of 1997, recognizing strongly the needs of rational use of energy and energy conservation.

3.2 Energy situation in Vietnam

In Vietnam , the main energy resources are coal, crude oil and hydro power. Almost of all natural gas produced in Vietnam is exported. The sources of energy supply account for by coal 25% and imported petroleum 59%. In 1995 consumption of commercial energy is in industry 52%, residencial/commercial 18% and transportation 30%.
Latent volume of coal and crude oil are expected very big. Cooperating with developed countries the research activities and production of coal and crude oil are increasing. Export ability of coal and oil are estimated to be increasing.
From 1991 to 1995, coal production increased from 2.7 million tons of oil equivalent to 3.3 million tons and about 27% was exported, and coal deposit are expected 20 billion tons. And about oil production is 3.95 million tons to 8.65 million tons, and in 2000 production will be expected 20 million tons.

Recent years, industrial productions, iron & steel, chemical products and others, are increasing rapidly, simultaneously, needs of investments are increasing. In order to have a balanced energy consumption and production, and to have a competitive power, it is strongly required the rational use of energy and energy conservation. In 1998, the government made the master plan for energy strategy.

3.3 UNIDO seminars

The UNIDO seminars were held with the aim of increasing awareness and knowledge of government officials and factory engineers in rational use of energy in rubber and iron casting industries, each seminar was attended 40 to 70 participants.

The observation made by experts during the plant surveys were presented and the energy conservation measures documented in the Handy Manuals on energy conservation in rubber and iron casting industries were discussed. The audience showed great deal of interest in the topics being presented, as reflected by their participation in the discussions.

3.4 Outputs and associated benefits

1) Participants mix:
The seminars were attended by a number of factory engineers who needed basic energy conservation know-how for factory operation. These seminars were also attended by plant managers and representatives from government and private sector. The extensive experience of ECC experts in various aspects of energy conservation was a relevant asset.

2) Government- Factories cooperation
The seminars facilitated a dialogue between government and private sector. This could be useful in future cooperation, as well as in establishing a better understanding among parties concerning the barriers and potential means to overcome them to achieve better energy management.

3) Transfer of information
The seminar provided potential opportunities for dissemination of information country wide, as well as from China and Vietnam to other developing countries.

4) Contribution of the counterparts
Due to the efforts of the counterparts of both countries, a positive atmosphere was created to bring about awareness of the participants regarding energy conservation in the targeted industries.

5) Additional discussions

In addition to the core programme, discussions were held concerning the findings which arose from the field surveys and factory energy audit. This demonstration gave the participants a better understanding of different aspects of energy conservation.

3.5 Evaluation of seminar by participants evaluation sheet

We gather the evaluation sheet from the participants at the end of seminar and go to the following answer.

1) Industry affiliation
   - Iron Casting 53%
   - Rubber 47%
2) Category
   - Management 54%
   - Technical 46%
3) Organization of seminar
   - Excellent 31%
   - Good 69%
4) Relevancy of topics covered
   - Very relevant 20%
   - Somewhere relevant 80%
5) Quality of materials presented
   - Excellent 18%
   - Good 63%
   - Adequate 19%
6) Quality of presentation
   - Excellent 24%
   - Good 62%
   - Adequate 14%
7) To what degree energy conservation is practiced at your plant?
   - Extensively 8%
   - Moderately 92%
8) How do you categorize the major energy conservation measures practiced at your plant
   - Housekeeping 30%
   - Equipment related 49%
   - Process related 15%
   - All three 6%

9) Are the energy conservation measures discussed at this seminar applicable to your plant

- Most are applicable 13%
- Some are applicable 70%
- None is applicable 18%

10) What are the chances for the applicable energy conservation measures being adopted by your plant ?

- Very good 16%
- Good 58%
- Not good 13%
- None 13%

11) What are the barriers to adoption of energy conservation measures by your plant ?

- Plant ownership 9%
- Lack of incentives 14%
- Plant condition 9%
- Economic 70%

12) Are the energy conservation technologies discussed at this seminar suitable for your country?

- Most are suitable 54%
- Some are suitable 46%

13) What are the barriers to transfer of the suitable energy conservation technology to your country ?

- Lack of support infrastructure 13%
- Lack of incentives 7%
- Economic 80%

Applicability of the seminar's contents to participant's factories is high as 83%. However lack of incentive and economic condition are barriers for adaptation of energy conservation measures.

Housekeeping and equipment related measures are major stage of energy conservation in participant's plant. Disseminate of these technologies are helpful to their plants.

Seminar's contents fit with each country's requirements for energy conservation.

3.6 Potential for propagation of energy conservation concept

The energy conservation methods can be promoted though the following activities.

- Seminar on success stories in iron casting and rubber industries
- Dissemination of information on energy conservation including energy audit through seminar and training program.
- Demonstration of improvement procedures for energy conservation
- Monitoring the effect of energy conservation

4. Schedule of the seminar

China

February	9	1998	Tokyo (10:30) to Beijing(13:35) NH905
	10		Preparation of seminar
	11		Preparation of seminar
	12		Seminar, Iron casting industry
	13		Seminar, Rubber industry
	14		Beijing (14:50) to Tokyo(19:00) NH906

Vietnam

February	22	1998	Tokyo (9:40) to Hanoi (15:55) CX791
	23		Preparation of seminar
	24		Preparation of seminar
	25		Seminar, Iron casting industry
	26		Seminar, Rubber industry
	27		Hanoi (9:55) to Tokyo (20:00) CX500

1) Seminar program in China

12 February 1998, at Holiday Inn Downtown, Beijing

Seminar on Energy Conservation in Rubber and Iron Casting Industries

8:30-9:00	Registration
9:00-9:40	Opening Ceremony Address by - Mr. Zuo Liming, Vice-Director, Conservation and Integrated Utilization, State Economic & Trading Commission (SETC) - Mr. Tomozou Morino, Director, Representative Office, Japan External Trade Organization - Dr. B. Sugavanam, Country Director, China United Nations Industrial Development Organization (UNIDO) -Mr. Hassan Nazemi, Environment & Energy Branch Industrial Sector & Environment Division, (UNIDO) -Ms.Yukie Kawaguchi, Manager, International Cooperation Department, The Energy Conservation Center, Japan (ECCJ)
9:40-10:10	Energy Conservation in Japan -Ms.Yukie Kawaguchi
10:10-10:30	Coffee Break
10:30-12:00	Energy Conservation in Iron Casting Industry -Mr. Yoshihisa Miyazaki, ECCJ
12:00-13:30	Lunch
13:30-15:00	Energy Conservation in Iron Casting Industry
15:00-15:30	Coffee Break
15:30-16:20	Q & A
16:30	Closing

13 February 1998, at Holiday Inn Downtown, Beijing

Seminar on Energy Conservation in Rubber and Iron Casting Industries

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8:30-9:00	Registration
9:00-9:10	Address by
	-Chinese VIP, Chemical Industrial Department
	-Mr. Hassan Nazemi, Environment & Energy Branch
	Industrial Sector & Environment Division, UNIDO
9:10-10:00	Energy Conservation in China
10:00-10:30	Coffee Break
10:30-12:00	Energy Conservation in Rubber Industry
	-Mr. Hiroshi Idei, ECCJ
12:00-13:30	Lunch
13:30-15:00	Energy Conservation in Iron Casting Industry
15:00-15:30	Coffee Break
15:30-16:20	Q & A
16:30	Closing

Picture on seminar (1)

Picture on seminar (2)

Seminar in Beijing

2) Seminar program in Vietnam

25 February 1998, at Green Park Hotel, Hanoi

Seminar on Energy Conservation in Rubber and Iron Casting Industries

---

8:00-8:30	Registration
8:30-9:20	Opening Ceremony Address by -Mr. Le Quoc Khanh, Vice President Minister, Ministry of Industry -United Nations Industry Development Orgnaization(UNIDO) -Japanese Embassy -Mr.Kazuki Tanabe, General Manager, International Cooperation Department, The Energy Conservation Center, Japan (ECCJ)
9:20-10:30	Energy Conservation in Iron Casting Industry -Mr. Yoshihisa Miyazaki, ECCJ
10:30-10:45	Coffee Break
10:45-12:30	Energy Conservation in Iron Casting Industry
12:30-13:30	Lunch
13:30-15:00	Discussion, Q & A
15:00	Closing

26 February 1998, at Green Park Hotel, Hanoi

Seminar on Energy Conservation in Rubber and Iron Casting Industries

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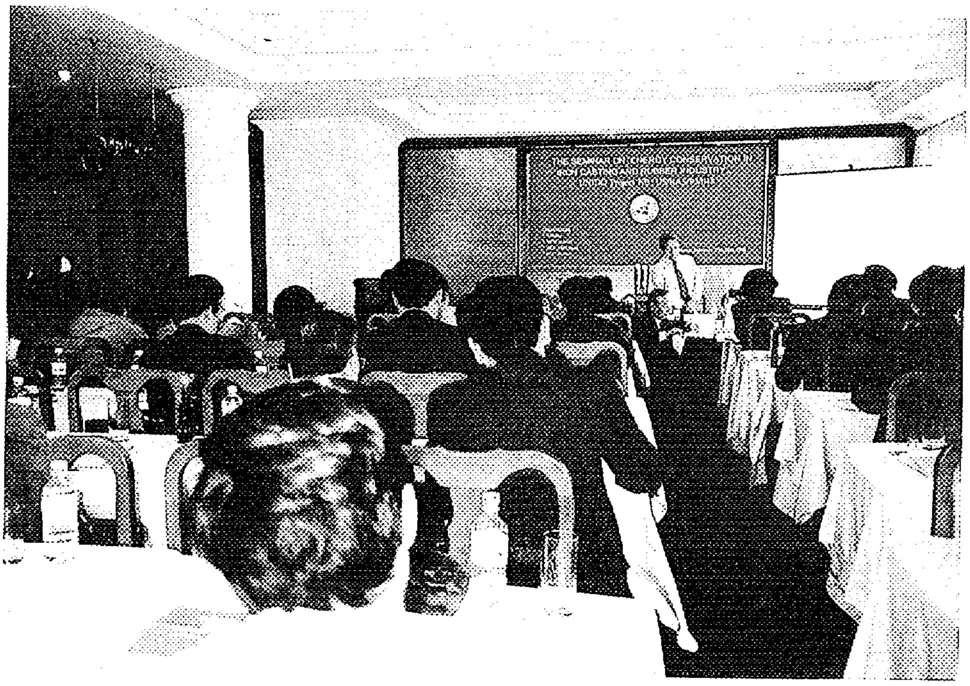
8:00-8:30	Registration
8:30-9:20	Opening Ceremony Address by -Mr. Le Quoc Khanh, Vice President Minister, Ministry of Industry -United Nations Industry Development Orgnaization(UNIDO) -Japanese Embassy -Mr.Kazuki Tanabe, General Manager, International Cooperation Department, The Energy Conservation Center, Japan (ECCJ)
9:20-10:30	Energy Conservation in Rubber Industry -Mr. Hiroshi Idei, ECCJ
10:30-10:45	Coffee Break
10:45-12:30	Energy Conservation in Rubber Industry
12:30-13:30	Lunch
13:30-15:00	Discussion, Q & A
15:00	Closing

Picture on seminar (1)



Picture on seminar (2)

Seminar in Hanoi

5. Schedule of the factory survey

No.	M	Day		Schedule
				Mr.Tanabe, Mr.Idei, Mr.Miyazaki
1	Sep	28	Sun	10:00 Lv.Narita (CX509) (Hong Kong Transit) 15:35 Ar.Hanoi (CX791)
2		29	Mon	Visit to JETRO, MOI, Japan Embassy, UNIDO
3		30	Tue	Survey at Research Institute of Technology for Machinery
4	Oct	1	Wed	Survey at Sao Van Rubber Company
5		2	Thu	Survey at Song Cong Diesel Engine Company
6		3	Fri	Survey at Thai Nguyen Iron & Steel Corporation
7		4	Sat	Off-day
8		5	Sun	Off-day
9		6	Mon	Visit and Discuss at MOI
10		7	Tue	10:10 Lv.Hanoi (VN790) (Hong Kong Transit) 18:10 Ar.Beijing (KA902)
11		8	Wed	Visit to SETC, UNIDO, JETRO
12		9	Thu	Survey at Beijing NO.1 Machine Tool Plant
13		10	Fri	Survey at Tianjin Internal Combustion Engine Factory
14		11	Sat	Off-day
15		12	Sun	Off-day
16		13	Mon	Survey at Beijing First Rubber Plant
17		14	Tue	Survey at Beijing First Rubber Factory
18		15	Wed	Survey at Beijing Tire Factory
19		16	Thu	Visit to Japan Embassy 15:00 Lv.Beijing (NH906) 19:15 Ar.Narita

6. Report of factory survey

6.1 Rubber industry in China

China (Rubber)

Factory name	Beijing Tire Factory 1997.10.13	Beijing No.2 Rubber Factory 1997.10.14	Beijing First Rubber Plant 1997.10.15
Place	Beijing	Beijing	Beijing
Products	Tire	V Belt	Bicycle Tire, etc
Annual sales	45,280Million Chinese Yuan/y	12,000Million Chinese Yuan/y	248,168,000 Chinese Yuan/y
Fule consumption			
1) Fuel oil	-	-	81.94 kl/y 155,014 Chinese Yuan/y
2) Diesel oil	0.91 kl/y	-	12.63 kl/y 39,346 Chinese Yuan/y
3) Kerosene	3.8 kl/y	-	1.29 kl/y 3,780 Chinese Yuan/y
4) Gasoline	520.8 kl/y	-	365.5 kl/y 832,085.57 Chinese Yuan/y
5) Coal	68,028 t/y	16,000 t/y 368 Million Chinese Yuan/y	24,823.5 t/y 6,340,534.07 Chinese Yuan/y
Electric power			
1) Electric consumption	38,721,000 kWh/y 14,048,967 Chinese Yuan/y	719 Million kWh/y 324 Million Chinese Yuan/y	17,119,200 kWh/y 7,039,846 Chinese Yuan/y
2) Power factor	88.6%	92%	90%
Water consumption			
1) Underground water	2,260,300 m^3	105 Million m^3	1,416,393 t/y
2) City water	-	-	5,367 t/y
Boiler			
1) Number	4 set	3 set	3 set
2) Fuel	coal	coal	coal
Energy use facility			
1) Air compressor	-	10 set	14 set
2) Heat exchanger	-	-	-
Energy cost/sales	6.2%	5.8%	5.8%
price of electricity (estimation):0.36-0.5Chinese Yuan/kWh price of coal (estimation):200Chinese Yuan/t price of oil (estimation):500Chinese Yuan/kl			
Energy conservation potential	1) Quality inspection of raw material 2) Energy management 3) Measurement of steam around vulcanization machines 4) Combustion control of boilers 5) Power factor control		

6.2 Iron Casting industy in China

China (Iron Casting)

Factory name	ianjin Internal Combustion Engine Factor 1997.10.9	Beijing No.1 Machine Tool Plant 1997.10.9
Place	Tianjin	Beijing
Products	Cylinder, Manifold	Milling Machine
Annual sales	20,000,000 Chinese Yuan/y	-
Fule consumption		
1) Fuel oil	-	-
2) Kerosene	45 kl/y	-
3) Coal	-	65 t/y
4) Coke	196 t/m	-
Electric power		
1) Electric consumption	6,960,000 kWh/y	-
2) Power factor	89%	-
Water consumption		
1) Underground water	-	77,986 m^3
2) City water	84,000 m^3/y	-
Boiler		
1) Number	-	-
2) Fuel	-	-
Energy use facility		
1) Air compressor	-	-
2) Heat exchanger	20.4%	-
Energy cost/sales		
price of electricity (estimation):0.5Chinese Yuan/kWh price of coal (estimation):200Chinese Yuan/t price of oil (estimation):500Chinese Yuan/kl		
Energy conservation potential	1) Energy management, reduction of energy total cost 2) Regulation of yield 3) Waste sheet recovery of cupola 4) Suitable control of blow rate for cupola 5) Power factor control	

6.3 Rubber industry in Viet Nam

Viet Nam (Rubber)

Factory name Visiting Dte	SAO VANG RUBBER COMPANY 1997.10.1
Place	Hanoi
Products	Tire tube, etc
Annual sales	20 mill US$
Fule consumption	
1) Fuel oil	-
2) Diesel oil	-
3) Coal	18,485 t/y
Electric power	
1) Electric consumption	10,638,000 kWh/y
2) Power factor	80%
Water consumption	
1) Underground water	2,880,000 m^3/y
2) City water	-
Boiler	
1) Number	5 set (1set stop)
2) Fuel:coal	6,550 t/y/set
Energy use facility	
1) Air compressor	5 set
2) Heat exchanger	-
Energy cost/sales	5%
price of electricity (estimation):4sent/kWh	
price of coal (estimation):25$/t	
Energy conservation potential	1) Energy management 2) Prevention of steam leakage 3) Combustion control of boilers 4)Improvement of the power factor 5) Power factor control

6.4 Iron Costing industry in Viet Nam

Viet Nam (Iron Casting)

Factory name	Research institute of echnology for Machiner 1997.9.30	Song Cong Disesel Engine Company 1997.10.2	Thai Nguyen Iron & Steel Corp. 1997.10.3
Place	Hanoi	Thai Nguyen Province	Thai Nguyen Province
Products	Cylinder, Liner	Diesel engine, Iron bars	Iron & Steel
Annual sales	630,000 US$	6 mill US$	1,800,000 US$
Fule consumption			
1) Fuel oil	-	-	10,746 kl/y
2) Diesel oil	5,000 l/y	-	-
3) Gasoline	9,000 l/y	60 kl/y	-
4) Coal	100 t/y	3,500 t/y	81,000 t/y
5) Coking coke	-	-	39,000 t/y
Electric power			
1) Electric consumption	444,445 kWh/y	18,000,000 kWh/y	261,289,000 kWh/y
2) Power factor	- %	- %	- %
Water consumption			
1) River water	-	500,000m^3/y	32,128,000m^3/y
2) City water	2,400 m^3/y	-	-
Boiler			
1) Number	-	-	2 set
2) Fuel	-	-	coal
Energy use facility			
1) Furnaces	11 set	-	BF, ENF, RM
2) Air compressor	-	2 set	-
Energy cost/sales	6%	16.8%	79.3%
price of electricity (estimation):4sent/kWh			
price of coal (estimation):25$/t			
price of coking Coke (estimation):30$/t			
Energy conservation potential	1) Energy management 2) Coke size control for cupola 3) Waste heat recovery of exhaust gas 4) Power factor control		

7.Japanese experts list

7.1 Field survey

1) Mr. Kazuki Tanabe
Metallurgical Engineer
General Manager, International Cooperation Department,
Japan International Energy and Environment Cooperation Center,
The Energy Conservation Center, Japan

2) Mr. Hiroshi Idei
Mechanical Engineer
Technical Advisor (Rubber),
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3) Mr. Yoshihisa Miyazaki
Metallurgical Engineer
Technical Advisor (Iron Casting),
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7.2 Seminar

1) Mr. Kazuki Tanabe
Metallurgical Engineer
General Manager, International Cooperation Department,
Japan International Energy and Environment Cooperation Center,
The Energy Conservation Center, Japan

2) Ms. Yukie Kawaguchi
Political Scientist
Manager, International Cooperation Department,
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The Energy Conservation Center, Japan

3) Mr. Hiroshi Idei
Mechanical Engineer
Technical Advisor (Rubber),
The Energy Conservation Center, Japan

4) Mr. Yoshihisa Miyazaki
Metallurgical Engineer
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The Energy Conservation Center, Japan

7.3 Home Office

1) Mr. Kazuki Tanabe
Metallurgical Engineer
General Manager, International Cooperation Department,
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2) Mr. Hiroshi Idei
Mechanical Engineer
Technical Advisor (Rubber),
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3) Mr.Yoshihisa Miyazaki
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8.Counterparts list

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9. Conclusion and recommendation for follow-up actions

Energy conservation opportunities in rubber and iron casting industries were identified in China and Vietnam through survey conducted in September to October in 1997, and seminars held in February 1998.

Our recommendation on the dissemination activities in energy conservation are as the following:

1) Dissemination activities in energy conservation technologies by Handy Manuals:

   The participants of the seminars may hold group meetings based on Handy Manuals in their companies and respective organizations.

2) Promotion of operation techniques improvement

   A) Rubber industry
      a) Quality inspection of raw material
      b) Repair of steam leakage
      c) Combustion control of boilers
      d) Record process data and manage energy consumption(energy management)

   B) Iron casting industry
      a) Regulation of yield
      b) Suitable preheat of ladle
      c) Prevent leak gas from the electric furnace top when melting
      d) Control the blow rate for cupola
      e) Energy management

3) Promotion of equipment improvement

   A) Rubber industry
      a) Hot insulation of steam pipe
      b) Repair the measurement instruments
      c) Power factor control

   B) Iron casting industry
      a) Control suitably grain size of coke for cupola
      b) Waste heat recovery of exhaust gas
      c) Power factor control

Appendix 1. List of the Surveyed Factories

Appendix.1 List of the Surveyed Factories

China

1) Rubber (three factories)

1. Beijing Tire Factory
   Products: Tire
   De Wai Xi San Qi, Beijing
   Tel. 86-10-62912244
   Fax. 86-10-62911341

2. Beijing No.2 Rubber Factory
   Products: Conveyor Belt
   Shunyi Railway Station, Beijing
   Tel. 86-10-69441596
   Fax. 86-10-69443319

3. Beijing First Rubber Plant
   Products: Bicycle Tire, etc
   Ban Bi Dian Western Surburb, Beijing
   Tel. 86-10-68187472
   Fax. 86-10-68187381

2) Iron Casting (two factories)

4. Tianjin Internal Combustion Engine Factory
   Products: Cylinder
   355, Nan Jing Road, Nankai District, Tianjin
   Tel. 86-22-27475700
   Fax. 86-22-27371708

5. Beijing No.1 Machine Tool Plant
   Products: Milling Machine
   4, Jian Guo Men Wai St.j Beijing
   Tel. 86-10-65061155
   Fax. 86-10-65023715

Vietnam

1) Rubber (one factory)

1. Sao Vang Rubber Company
   Products:Tire tube, etc
   231, Nguyen Trai Str, Hanoi
   Tel. 84-4-8584332
   Fax. 84-4-8583644

2) Iron Casting (three factories)

2. Research Institute of Technology for Machinery
   Products: Cylinder, Liner
   291, Lang Ha Dong Da-Ha Noi, Hanoi
   Tel. 84-4-8533322

3. Song Cong Diesel Engine Company
   Products: Diesel Engine
   Song Cong Town, Thai Nguyen Province
   Tel. 84-28-0862263
   Fax. 84-28-0862265

4. Thai Nguyen Iron & Steel
   Products: Iron & Steel
   Thai Nguyen Town, Thai Nguyen Province
   Tel. 84-28-0832066
   Fax. 84-28-0832056

Appendix 2. Participants List of the Seminar

Appendix
Beijing::

Participants List of the Seminar
12 February 1998

S NO.	NAME	DESIGNATION	ORGANIZATION
1	Zuo Liming	Vice Department Chief	Resource Department of State Economic and Trade Commission
2	B. Sugavanam	Country Director-China	United nations Industrial Development Organization
3	A. Hassan Nazemi	Industrial Development Officer	United nations Industrial Development Organization
4	Xie Ji	Chief Officer	Resource Department of State Economic and Trade Commission
5	LЧ Wenbin	Engineer	Resource Department of State Economic and Trade Commission
6	Wang Jianye	Department chief	Production Department of Machine-Building
7	Sheng Xijun	Vice Chief Officer	Production Department of Machine-Building
8	Kawaguchi Yukie	Section Chief	ECCJ
9	Miyazaki Yoshihisa	Expert	ECCJ
10	Idei Hiroshi	Expert	ECCJ
11	Hirono Yuzo	Superintendent	Japanese Embassy Promotion Association
12	Chi Yongshan		Beijing Heavy Electric Machine Plant
13	Cao Huiqing	Senior Economist	Automobile Department of Machine-Building
14	Wei Guowen	Senior Engineer	Beijing People Machine Factory
15	Ma Guishan	Vice Secretary-general	Chinese Mechanical Energy-Saving and Material-Saving technical Society
16	Liu Yingzhou	Director	Energy-Saving Center of Machine-Building Ministry
17	Zhang Weixiang		Beijing Heavy Electric Machine Plant
18	Shen Rong		Chinese Mechanical Energy-Saving and Material-Saving technical Society
19	Zhang Gusheng		Beituo Inc.
20	Yan Xinrui		Beituo Inc.
21	Fan Liguo	Factory Director	Beijing Heavy Enginery Plant
22	Zhang Runyi		Beijing Heavy Enginery Plant
23	Zhou Ying		Beijing Heavy Enginery Plant
24	B.SUGAVANAM		UNIDO
25	A.		
26	J.		
27	Xu Guangzhi	Cadre	Beijing First Machine Tool Works-Power Plant
28	Hao Zhongli	Engineer	Beijing First Machine Tool Works
29	Yun Shuo	Senior Engineer	Beijing First Machine Tool Works
30	Tu Fengshi	Senior Engineer	Beijing First Machine Tool Works
31	Song Hanchen	Senior Engineer	Beijing First Machine Tool Works
32	Fu Hongkun	Cadre	Beijing First Universal Mechanical Plant
33	Wang Xiaoming	Cadre	Beijing Second Machine Tool Works
34	Feng Ximing	Cadre	Beijing Second Machine Tool Works
35	Zhang Yisheng	Cadre	Bei Stock Company
36	Jiao Baolin	Cadre	Beijing Second Machine Tool Works
37	Guo Haibo	Cadre	Beijing Demos Machine Factory
38	Hu Zhiqiang	Cadre	Administrative Bureau of Beijing Mechine Building
39	Cao Huiqing	Chief Officer	Ministry of Mechine Building
40	Ren Haicheng	Engineer	Beijing First Machine Tool Works
41	Li Zaiheng	Secretary	UNIDO
42	Gao Bing	Assistant Engineer	Beijing Heavy Enginery Plant
43	Wang Jinrong	Engineer	Beijing D-Type Power Machine Plant
44	Zhang Desheng	Vice Group Chief	Tianjin Electromechanical Industry head Office
45	Cui Quanxiang		Tianjin Electromechanical Industry head Office
46	Liu Huaiwei		Tianjin Electromechanical Industry head Office
47	Ding Yungui	Cadre	Tianjin Internal-Combustion Engine Branch Office
48	Lu Wensheng		Tianjin Internal-Combustion Engine Branch Office
49	Liu Zengcheng	Cadre	Tianjin Internal-Combustion Engine Branch Office
50	Wang Xiaqing	Director	Tianjin Internal-Combustion Engine Branch Office
51	Liu Quanxi	Cadre	Tianjin Internal-Combustion Engine Branch Office
52	Zou Linping	Cadre	Beijing Electric Machine General Factory
53	Yang Haisen	Cadre	Beijing Electric Machine General Factory
54	Dong Lie	Vice Secretary-General	Chinese Energy-Saving Society
55	Wang Jing	Engineer	Chinese Energy-Saving Society
56	Jiang Yun	Engineer	Chinese Energy-Saving Society

Appendix Participants List of the Seminar
Beijing:: 13 February 1998

S NO.	NAME	DESIGNATION	ORGANIZATION
1	Zuo Liming	Vice Department Chief	Resource Department of State Economic and Trade Commission
3	A. Hassan Nazemi	Industrial Development Officer	United nations Industrial Development Organization
3	Xie Ji	Chief Officer	Resource Department of State Economic and Trade Commission
4	LЧ Wenbin	Engineer	Resource Department of State Economic and Trade Commission
5	Dong Jianyue	Vice Department Chief	Product Coordination Department of Chemical Industrial Ministry
6	Zeng Guang'an	Senior Engineer	Former Ministry of Chemical Industry
7	Xu Fei	Chief Officer	Product Coordination Department of Chemical Industrial Ministry
8	Yang Mingkai	Vice Chief Officer	Product Coordination Department of Chemical Industrial Ministry
9	Kawaguchi Yukie	Section Chief	ECCJ
10	Idei Hiroshi	Expert	ECCJ
11	Miyazaki Hisashi	Expert	ECCJ
12	Gao Jincheng	Senior Engineer	Second Rubber Plant
13	Gao Ruichun	Senior Engineer	Second Rubber Plant
14	Luo Yanmin	Engineer	Second Rubber Plant
15	Wang Zhicheng	Engineer	Second Rubber Plant
16	Zhao Mingxin	Engineer	Second Rubber Plant
17	Name	Profession	Organization one belongs to
18	Zhong Ying	Engineer	Zhonglian Rubber, Group, Head Office
19	Zang Lihua	Engineer	Zhonglian Rubber Group Head Office
20	Liu Jie	Engineer	Rubber & Plastic Plant
21	Li Qinghua	Engineer	Rubber & Plastic Plant
22	Li Yuyong	Engineer	Rubber & Plastic Plant
23	Zhang Hongying	Engineer	Beijing Tyre Factory
24	Gong Dianchen	Engineer	Beijing Tyre Factory
25	Lu Shiyun	Vice Chief Engineer	Beijing Rubber Industry Research and Design
26	Li Fengying	Senior Engineer	Beijing Rubber Industry Research and Design
27	Li Ruoxiang	Senior Engineer	Beijing Rubber Industry Research and Design
28	Zhang Jie		Energy Sources Monitoring Station of Chemical Head
29	Zhao Zhiwei		Beijing Tyre Factory
30	Geng Xiuqin		Beijing Rubber Hardware Plant
31	Zhang Yan	Superintendent	Beijing First Rubber Plant
32	Chen Ming	Director of Branch Company	Beijing First Rubber Plant
33	Name	Profession	Organization one belongs to
34	Li Zaiheng	Secretary	UNIDO
35	Chen Xi	Engineer	Rubber Institute of Chemical Industrial Ministry
36	Dong Lie	Vice Secretary-General	Chinese Energy-Saving Society
37	Wang Jing	Engineer	Chinese Energy-Saving Society
38	Jiang Yun	Engineer	Chinese Energy-Saving Society

Appendix 2. Participants List of the Seminar

Hanoi, Vietnam: 25 February 1998 (Iron casting field)

S.NO.	NAME	DESIGNATION	ORGANIZATION
1.	Le Quoc Khanh	Vice Minister	Ministry of Industry (MOI)
2.	Mikeal Brenning	Director	UNIDO Vietnam
3.	Nazemi Hassan	Expert	UNIDO Vienna
4.	Nguyen Khac Tiep	Officer	UNIDO Vietnam
5.	Kazuki Tanabe	General Director of ECCJ	ECCJ
6.	Yoshihisa Miyazaki	Expert	ECCJ
7.	Hiroshi Idei	Expert	ECCJ
8.	Dang Ngoc Tung	Director of Dept for Technologycal and Product's quality management (TPQM)	MOI
9.	Do Van Hai	Deputy Director Dept. for Industry	Ministry of Planning and Investment (MPI)
10.	Thai Ba Minh	Deputy Director of TPQM	MOI
11.	Nguyen Xuan Xuong	Deputy Director of TPQM	MOI
12.	Do Dang Hieu	Deputy Director of TPQM	MOI
13.	Bui Van Hung	Attache	MOI
14.	Nguyen Thi Thanh	Attache	MOI
15.	Nguyen Dinh Hung	Attache	MOI
16	Chu Duc Khai	Attache	MOI
17.	Vu Do Dung	Attache	MOI
18.	Tran Van Bien	Attache	MOI
19.	Nguyen Dac Hung	Attache	MOI
20.	Do Hong Hai	Attache	MOI
21.	Nguyen Manh Khai	Deputy Director of Minister's Office	MOI
22.	Pham Chi Cuong	Vice Chairman	Vietnam Steel Co. (VSC)
23.	Nguyen Kim De	Chief of Technical Section	VSC
24.	Pham thi Hang	Attache	VSC
25.	Dinh Van Tam	Attache	VSC
26.	Dang Van Siu	Vice General Director	Thai Nguyen Iron & Steel Co. (TISCO)
27.	Nguyen Khoa Phi	Chief of Technical Section	TISCO
28.	Nguyen Van Mai	Vice Chief of Technical Section	TISCO
29.	Doan Dinh Phat	Technician	TISCO
30.	Le Bao	Director of Iron ore mine	TISCO
31	Nguyen Trong Hoa	Chief of Technical Section Gia Sang Mill	TISCO
32.	Tram Trong Mung	Director of Mechanical Plant	TISCO
33.	Dinh Van Nhuan	Chief of Metallurgical Section Mechanical Plant	TISCO
34.	Do Viet Dan	Director of Luu Xa Steelmaking Plant	TISCO
35.	Nguyen Van Thinh	Director of Energy Enterprise	TISCO

36.	Dau Van Hung	General Director	Southern Steel Co.(SSC)
37.	Dao Chau Son	Deputy Director	SSC
38.	Tran Quang Hai	Chief of Technical Section	SSC
39.	Nguye Van Hai	Director of Tan Thuan Steel Plant	SSC
40.	Pham Manh Cuong	Vice Director of SADAKIM	SSC
41.	Le Tan Quan	Chief of Technical Section SADAKIM	SSC
42.	Son Sa Ranh	Chief of Technical Section Tan Thuan Steel Plant	SSC
43.	Nguyen Van Sua	Director	Ferrous Metallurgy Institute(FMI)
44.	Le Van Nguyen	Chief of R&D Section	FMI
45.	Bui Ngoc Tuong	Chief of Steel Shop	FMI
46.	Nguyen Hoa	Director of Casting Shop	Hanoi Mechanical Co.(HMCo)
47.	Pham Ngoc Thach	Vice Chief of Metallurgical Section	HMCo
48.	Tran Cay	Chief of Casting Shop	Hai Duong Pump Co. (HPC)
49.	Le Binh	Technician	HPC
50.	Ngo Van Tuyen	Director	Song Cong Diesel Co(DISCO)
51.	Tran Dinh Chien	Chief of Energy Section	DISOCO
52.	Do Dinh Su	Chief of Casting Shop	DISOCO
53.	Nguyen Van Duong	Chief of Mechanical Shop	DISOCO
54.	Nguyen Van Tan	Director	Technological Institute(TI)
55.	Tran Van Ban	Vice Director	TI
56.	Nguyen Van Chuong	Vice Director	TI
57.	Nguyen Thanh Huong	Researcher	TI
58.	Phan Cong Hop	Vice Chief of General Section	TI
59.	Hoang Anh Chau	Chief of Casting Section	TI
60.	Trinh Van Bat	Vice Chief of Casting Section	TI
61.	Nguyen Kim Phuon	Vice Chief of Casting Section	TI
62.	Dao Huan Ngu	Researcher	TI
63.	Pham Thi Mui	Researcher	TI
64.	Chu Xuan Tinh	Researcher	TI
65.	Do Thanh Liem	Technician	Machineries for Agriculture Co.
66.	Do Sy Nang	Technician	Machineries for Agriculture Co.
67.	Hoang Van Du		Industry Magazine
68.	Dang Kim Duyen		Interpreter

Hanoi, Vietnam: 26 February 1998 (Iron casting field)

S.NO.	NAME	DESIGNATION	ORGANIZATION
1.	Le Quoc Khanh	Vice Minister	Ministry of Industry (MOI)
2.	Mikeal Brenning	Director	UNIDO Vietnam
3.	Nazemi Hassan	Expert	UNIDO Vienna
4.	Nguyen Khac Tiep	Officer	UNIDO Vietnam
5.	Kazuki Tanabe	General Director of ECCJ	ECCJ
6.	Yoshihisa Miyazaki	Expert	ECCJ
7.	Hiroshi Idei	Expert	ECCJ
8.	Dang Ngoc Tung	Director of Dept for Technological and Product's quality management (TPQM)	MOI
9.	Do Van Hai	Deputy Director Dept. for Industry	Ministry of Planning and Investment (MPI)
10.	Thai Ba Minh	Deputy Director of TPQM	MOI
11.	Pham Duc Luong	Deputy Director of TPQM	MOI
12.	Bui Van Hung	Attache	MOI
13.	Nguyen Thi Thanh	Attache	MOI
14.	Chu Duc Khai	Attache	MOI
15.	Vu Do Dung	Attache	MOI
16	Pham Thi Chiu	Attache	MOI
17.	Tran Dat	Attache	MOI
18.	Tran Van Bien	Attache	MOI
19.	Do Hong Hai	Attache	MOI
20.	Nguyen Manh Khai	Deputy Director of Minister's Office	MOI
21.	Luong Van Cau	Deputy Director	Vietnam Chemical Corp.(VCCo)
22.	Nguyen Tien Toat	Chief of Technical Section	VCCo
23.	Tran Thi Hanh	Vice Chief of Technical Section	VCCo
24.	Le Hung	Technician	VCCo
25.	Pham Duc Phat	Vice Chief of International Relation Section	VCCo
26.	Huong	Vice Chief of Planning Section	VCCo
27.	Tran Van Tu	BOM Member	VCCo
28.	Dinh Van Nghi	BOM Member	VCCo
29.	Vu Quang Trinh	Thu Ky Hoi dong quan tri	VCCo
30.	Nguyen Duy Dang	Director	Golden star Rubber Company (GSRCo)
31	Pham GiaChuy	Vice Director	GSRCo
32.	Tran Ky Vu	Chief of Mechanical Section	GSRCo
33.	Luong Quy Ba	Technician	GSRCo
34.	Pham Van Ba	Technician	GSRCo
35.	Duong Thi Thang	Chief of Technological Section	GSRCo
36.	Nguyen Thi Loan	Vice Chief of Technological Section	GSRCo
37.	Le Thao Hien	Chief of Quality Control Section	GSRCo
38.	Le Cong An	Director of Energy Enterprise	GSRCo

39.	Nguyen Van Minh	Vice Director of Energy Enterprise	GSRCo
40.	Le Anh Tuan	Director of Tubes and Tires for motobike Enterprise	GSRCo
41.	Pham Gia Tuong	Director of Tubes and Tires for bycicle Enterprise	GSRCo
42.	Vu Quoc Khanh	Director of Tires for automobile Enterprise	GSRCo
43.	Nguyen Van Kinh	Director of Tubes and Tires for bycicle and motorbike Enterprise	GSRCo
44.	Dao ngoc Hung	Technician	GSRCo
45.	Pham Thanh Hoang	Director	Danang Rubber Co. (DRCo)
46.	Dinh Ngoc Dam	Vice Director	DRCo
47.	Phan Thanh Diep	Vice Director	DRCo
48.	Truong Chi Thinh	Vice Director	DRCo
49.	Nguyen Hoai Nam	Director of Energy Enterprise	DRCo
50.	Pham Quang Vinh	Chief of Mechanical Section	DRCo
51.	Le Binh Thuan	Director	South Rubber Co. (SRCo)
52.	Ngyuen Quoc Anh	Vice Director	SRCo
53.	Pham Duy Nha	Chief of Mechanical Section	SRCo
54.	Pham Quang Ginog	Director	Thai Binh Rubber Co.
55.	Tran Tich Tien	Director	Xuan Hoa Joint Venture Rubber Co. (XHJVRCo)
56.	Sadao Yamaguchi	Vice Director	XHJVRCo
57.	Nguyen Truong Thu	Technician	XHJVRCo
58.	Nguyen Duc Hong	Technician	XHJVRCo
59.	Duong Thi Hai Van	Technician	XHJVRCo
60.	Pham Thi Minh Thu	Technician	XHJVRCo
61.	Do Quang Tri		Hocmon Rubber Co.
62.	Hoang Van Du		Industry Magazine

Appendix 3. Opening Address of Chief Guest at the Seminar

Address in opening ceremony of "Seminar on Energy Conservation in Iron Casting & Rubber Industry"

By Mr. Zuo Liming, Vice Director,
Bureau of Conservation and Integrated Utilization
State Economic & Trading Commission P.R.C.

Mr. Tomozou Morino
Director, Beijing Office, Japan External Trade Organization
Mr. B. Sugavanam
UNIDO Coountry Director – China
Mr. Hassan Nazemi
Industrial Development Officer, UNIDO

Good morning ladies and gentlemen, and welcome to the Energy Conservation Seminar of UNIDO. My name is Zuo Liming and I am the vice-director of Bureau of Conservation and Integrated Utilization, State Economic & Trading Commission, P.R.C. I am speaking on behalf of the Commission. Since promoting energy conservation, resource conservation, and environmental conservation are very important tasks for China at present, it is very significant to have exchanges of energy conservation technologies at the energy saving seminar held here today, which is so well attended.

I consider it very important and indispensable for China to study advanced energy conservation technologies, as well as energy management methods, to promote energy conservation in China. It is very significant to China to learn from Japan's extensive experience of energy conservation measures including related laws, regulations, and policies.

In China, the Energy Conservation Law was introduced last year. Priority is being given to promoting energy conservation in the energy policy this year, thereby strengthening the political approach to the task. In China, however, energy conservation has great potential because of our large energy consumption and low energy efficiency ratio, and radical measures are needed against worsening environmental pollution.

I trust that the technological exchanges will succeed in helping China solve the important problems with which it is confronted. Thank you very much.

Address in opening ceremony of "Seminar on Energy Conservation in Iron Casting & Rubber Industry"

by Mr. MORINO, Director, Beijing Liaison Office,
Japan External Trade Organization

Mr. Zuo Liming
Vice-Director, Bureau of Conservation and Integrated Utilization
State Economic & Trading Commission P.R.C.
Mr. B. Sugavanam
UNIDO Country Director - China
Mr. Hassan Nazemi
Industrial Development Officer, UNIDO

Good morning ladies and gentlemen, and welcome to the Energy Conservation Seminar of UNIDO. My name is Morino and I am the director of the Beijing Liaison Office of Japan External Trade Organization. Japan External Trade Organization has been working hard to promote friendly relations between Japan and China. It is a great pleasure for me to find the seminar held here today so well attended. I believe the diffusion of advanced energy conservation technologies from Japan will further contribute to deepening friendly relations between the two countries through close cooperation with UNIDO.

I am told that the cooperation of Japan and China in the field of energy conservation started in 1981 and the Energy Conservation Training Center was set up in Da Lian in 1994 through international cooperation between Japan and China. I trust that the Center is now making a great contribution to promoting energy conservation in China through human resources development in the field of energy conservation.

In recent years, many Japanese enterprises have been making inroads into the Chinese market, sustaining the very good friendly relations between Japan and China. It is worth noting that the spectacular economic development of China as a whole has centered around Beijing. I believe that China will continue to develop in the future, thereby strengthening its industrialization. However, it is anticipated that the approaches taken to the effective use of energy and global environmental conservation will become more important tasks with sharply increasing energy consumption in China. The target for the reduction of carbon dioxide emissions to prevent global warming was decided for advanced nations at COP3 in Kyoto, and the importance of cooperative support for developing nations was properly recognized. Under such circumstances, the role of energy conservation in preventing global warming is highly evaluated at present, and it will become one of the most important tasks throughout the world in the future.

Against this background, an investigation on energy conservation was conducted at factories manufacturing cast iron and rubber in October last year. I believe that the manual of energy conservation prepared based on the results of the investigation and presented to you today will be of great use in promoting energy conservation in China. I trust that the positive approaches of the Chinese government to energy conservation including the investigation and the present seminar will further promote energy conservation in China as a whole.

Finally, I sincerely wish that communications between Japan and China will be deepened through the successful results of this seminar and international cooperation for energy conservation. Thank you very much.

Energy Conservation Seminar, Beijing.

Closing Ceremony, Feb.13, 1998.

Statement from UNIDO Country Director, Mr.B.Sugavanam.

Good Afternoon Ladies and Gentlemen.

During the last two days, the seminar covered energy conservation in iron casting and rubber industries. I am sure the two- day proceedings would have given, for both who attended the yesterday seminar on iron casting industry and those attending to day's seminar on energy conservation in rubber industries, a number of ways and means of energy conservation based on Japanese experience. I gather that the programme is intended to understand, discuss and agree on the manuals prepared jointly by UNIDO and the Energy Conservation Centre,(ECC) Japan. I hope the lectures would have stimulated very interesting Q and A period both yesterday and today.

UNIDO is going through a major reorganization in order to give a better service to its clients in the field where it matters. In its new structure, which was announced only this week , February 9, 1998, UNIDO is setting up two new Branches one on Energy Conservation and another one on Cleaner Production, both relevant to this two-day seminar. So it was very appropriate that within the same week of our restructuring announcement, UNIDO along with SETC and ECC, Japan organized this two-day seminar on Energy Conservation.

In the new set up, our office here in Beijing will get more authority and staff to meet the country's requirements. Therefore this seminar is a good start for my office and SETC to discuss further as to how to follow up the seminar results and recommendations.

In the opening day yesterday it was mentioned about the enactment of energy conservation law in China. UNIDO would be very much interested to assist in capacity building to implement the law in cooperation with SETC to disseminate information, training of trainers and even setting up of Energy Conservation Networks (Provincial, National and even Regional covering other countries involved in this regional project) in each sector. This could also include water conservation along with energy. Such networks would assist the State Operated Enterprises (SOEs) in energy and water conservation. This will have a multiplier effect which will be not only beneficial to national/regional economy but also will provide direct support to Kyoto Directive on Global Warming.

My office here in Beijing would be very pleased to take it up with SETC, UNIDO Head Quarters and ECC, Japan and apply for funds to set up such networks which would promote Environment friendly technologies in various industry sectors through training, information exchange, and linkage with institutions like the ECC, Japan and others. .

I want to thank the organizers, the participants of both yesterday and today for the successful completion of the two-day seminar on Energy Conservation.

SEMINAR ON
RATIONAL USE OF ENERGY SAVING TECHNOLOGIES IN IRON CASTING AND RUBBER INDUSTRIES IN CHINA AND VIETNAM
presented at the opening session
by A.H. Nazemi

February 12, 1998

In 1991, UNIDO initiated a new program, "Rational Use of Energy Saving Technologies," designed to increase awareness and knowledge of government officials and industrial users on appropriate energy saving processes and technologies. Since 1991, under continuos financial support from the Government of Japan, we have implemented four projects in eight different industrial sub-sectors in eight countries.

Basically, each project entails:

1. Surveys of a number of selected factories in the target sub-sectors to characterize their energy usage and identify measures to improve their energy efficiency.

2. Prepare handy manuals on energy management;

3. Organize seminars to discuss the contents of the handy manuals and the findings of the plant surveys.

This year, our fifth project under the above programme is being done in China and Vietnam, targeting two energy intensive industrial sub-sectors: iron casting and rubber industries. We visited a number of factories in China to learn first hand how the manufacturing process in the two target sub-sectorsare conducted here, and what measures are employed to improve energy efficiency. I am pleased to report that not only we enjoyed the plant visits, but also learned how advanced these technologies are in this country. We appreciate the kindness and hospitality that we received during our visits to the factories, and the courtesy extended to us in arranging plant tours and answering our numerous questions.

Today, we are here to discuss with you what we saw and what we learned, and also to present to you some energy conservation ideas practised elsewhere. We sincerely hope that these sessions would serve as a forum to exchange ideas and learn more about each other ways in dealing with the important issue of energy conservation.

In conclusion, I would like to wish you a productive seminar, and thank you for your participation.

GREETING AND OPENNING SPEECH

read by Vice Minister LE QUOC KHANH, **MINISTRY OF INDUSTRY.**

Seminar on " Energy Conservation in Iron casting and Rubber industry"

Project No : US/RAS/95/048.

Hanoi Feb. 25th. and 26th, 1998.

To: - Mr. Nazemi, UNIDO officer in Vienna
- Mr. Mikael Brening, Country Director, UNIDO Vietnam
- The experts Delegation from Energy Conservation Center, Japan.
- To the distinguish guests who come from Ministry of Planing and Investment.
- To all of you.

In developing countries in general speaking and Vietnam in special case, the way of using energy not yet to give high efficiency due to back ward in Technology equipments, low productivity and orgamizing of production having problems. These short-coming leading to energy high consumption but giving low economics values, and together with more emission gases, polluted ecological environment.

From that problems for many year, UNIDO providing technical assistance to developing countries in the field of Energy management, which belong to different industries such as Iron and steel, textile, paper, glass, rubber in Malaysia, Indonesia, Philippines, Thailand, Srilanka, Bangladesh, Pakistan, India and this year are China and Vietnam. The project bearing the name of: " program for Rational use of Energy Saving Technologies in Iron Casting and Rubber Industry - China and Vietnam". The project number: US/RAS/95/048.

Come to our goal is industrial developing in Environmental sustainable: UNIDO are concentrating their efforts to help developing countries in General Energy management and together with Energy Conservation in different industries where using big amount of Energy consumption.

In this field, Japan is leading country having high ratio of Energy efficiency in terms of total energy requirements per unit of GNP. Go ahead in this field is Energy conservation center of Japan (ECCJ) who was selected by UNIDO as counter part on this project.

During carry-out this project, ECCJ experts having very closed cooperation to the experts from Ministry of Industry, deeply survey in production of Iron casting and rubber industry to determine the reasons of pour energy management and giving good solutions to help plants reducing energy consumption, low cost, increasing competition capability of home made goods and reducing the pollution to environment. That is our main purpose of seminar to day.

On this occasion, kindly allow me to be on behalf of Ministry of Industry, on behalf of Vietnam Government, I would like to say many thanks to UNIDO and highly encourage the efforts of ECCJ experts with Vietnamese experts .

I am hoping that by these seminars, our plants/institutes in Iron casting and Rubber production will learn more and more experiences in the field of using and energy management. All of good experiences should be propagate to other industries.

Kindly allow me to declare opening the seminar on "Energy Conservation in Iron casting and Rubber industries".

Thank you for listening.

Address in opening ceremony of "Seminar on Energy Conservation in Iron Casting & Rubber Industry"

By Mr. Wada, 1st Secretary, Embassy of Japan

Mr. Le Quockhanh
Vice Minister, Ministry of Industry
Mr. Hassan Nazemi
UNIDO Officer in Vienna
Mr. Mikael Brening
Country Director, UNIDO Vietnam

Good morning ladies and gentlemen, and welcome to the Energy Conservation Seminar of UNIDO. I am substituting for Mr. Wada, a first secretary of the Japanese Embassy. I am speaking on behalf of the Japanese Embassy in Vietnam. The Japanese Embassy has been working hard to promote friendly relations between Japan and Vietnam. It is a great pleasure for me to find the seminar held here today so well attended. I believe the diffusion of advanced energy conservation technologies from Japan will further contribute to deepening friendly relations between the two countries through close cooperation with UNIDO.

I am told that the cooperation of Japan and Vietnam in the field of energy conservation started in 1994 and has been making a great contribution to promoting energy conservation in Vietnam through investigations and seminars.

In recent years, many Japanese enterprises have been making inroads into the Vietnamese market, sustaining the very good friendly relations between Japan and Vietnam. It is worth noting that the spectacular economic development of Vietnam as a whole has centered around Hanoi and Ho Chi Minh City. I believe that Vietnam will continue to develop in the future, thereby strengthening its industrialization. However, it is anticipated that the approaches taken to the effective use of energy and global environmental conservation will become more important tasks with sharply increasing energy consumption in Vietnam. The target for the reduction of carbon dioxide emissions to prevent global warming was decided for advanced nations at COP3 in Kyoto, and the importance of cooperative support for developing nations was properly recognized. Under such circumstances, the role of energy conservation in preventing global warming is highly evaluated at present, and it will become one of the most important tasks throughout the world in the future.

Against this background, an investigation on energy conservation was conducted at factories manufacturing cast iron and rubber in September and October last year. I believe that the manual of energy conservation prepared based on the results of the investigation and presented to you today will be of great use in promoting energy conservation in Vietnam. I trust that the positive approaches of the Vietnamese government to energy conservation including the investigation and the present seminar will further promote energy conservation in Vietnam as a whole.

Finally, I sincerely wish that communications between Japan and Vietnam will be deepened through the successful results of this seminar and international cooperation for energy conservation. Thank you very much.

SEMINARS ON
RATIONAL USE OF ENERGY SAVING TECHNOLOGIES IN IRON CASTING AND RUBBER INDUSTRIES IN CHINA AND VIETNAM

Presented at the opening session
by A.H. Nazemi
25 February 1998

In 1991, UNIDO initiated a new programme, "Rational Use of Energy Saving Technologies," designed to increase awareness and knowledge of government officials and industrial users on appropriate energy saving processes and technologies. Since 1991, under continuous financial support from the Government of Japan, we, in collaboration with The Energy Conservation Center, Japan (ECCJ), have carried out four projects in eight different industrial sub-sectors in eight countries.

Basically, each project entails:

1. Surveys of a number of selected factories in the target sub-sectors to characterize their energy usage and identify measures to improve their energy efficiency.

2. Prepare handy manuals on energy management.

3. Organize seminars to discuss the contents of the handy manuals and the findings from the plant surveys.

This year, our fifth project under the above programme is being done in Vietnam and China, targeting two energy intensive sub-sectors: iron casting and rubber industries. Late last year, a team consisting of Vietnamese experts, ECCJ and UNIDO visited a number of factories in this country to learn first hand about manufacturing processes used in the two target sub-sectors, and about the measures employed to improve energy efficiency.

I am pleased to report that our plant visits were very productive. We collected pertinent information and learned a lot about your ideas and conventions. We appreciate the kindness and hospitality that we received during our visits to your factories, and the courtesy extended to us in arranging plant tours and answering our numerous questions.

Today, we are here to discuss what we saw and what we learned, and to present some relevant technologies and energy conservation measures utilized elsewhere. Furthermore, we hope that these sessions would serve as a forum to exchange ideas and learn more about each other ways in dealing with the important issue of energy conservation.

In closing, I would like to express my sincere appreciation to: The Ministry of Industry of SR of Vietnam for hosting this seminar and their assistance in its organization; The Ministry of Trade and Industry of Japan for financing this project; The Energy Conservation Center, Japan for their hard work in organizing this seminar; and to all of you for your participation. Thank you.

SR V. Socialist Republic of Vietnam

Appendix 4. News Release on the Seminar

節能信息報

JIE NENG XIN XI BAO

中国节能协会主办

1998年2月28日 星期六 第4期 (总第313期)

我国年发电量装机容量居世界第二

全国电力科技工作会议2月16日在京召开，李鹏总理、宋健国务委员为大会召开题了词。李鹏总理的题词是“实现科教兴电，促进电力发展”。宋健国务委员的题词是“提高科技创新能力，实现电力工业现代化”。

电力部副部长陆延昌在会上说，为了实现电力工业的可持续发展，电力科技到2000年的奋斗目标是，科技进步对电力工业经济增长的贡献率提高5至10个百分点；到2010年，电力工业的科技实力接近达到国际先进水平。电力信息化技术水平达到同期国际水平，高新技术的研究开发与发达国家同步，为实现电力工业现代化，跻身世界先进行列奠定基础。

电力部提供的资料显示，改革开放以来，我国电力工业取得了令世人瞩目的成绩。1987年，全国发电装机容量达到1亿千瓦，1995年3月又突破了2亿千瓦。1997年底，全国发电装机总容量已达2.5亿千瓦；年发电量达到了11350亿千瓦时，均居世界第二，在电力工业的持续、快速发展中，科技进步起到了十分突出的作用。从80年代初起，电力科技采取引进——消化吸收——攻关创新的策力，在短期内取得了一大批实用性科技成果，使我国的电力工业在装备、设计、施工、运行和经营管理等方面跨上新台阶，大大缩短了与世界先进水平的差距，为我国电力工业的现代化打下了扎实的基础。

中日铸造、橡胶节能研讨会在京举行

本报讯　为了协助日本通商产业省、日本节能中心完成联合国工发组织关于编制节能技术指南的项目，由日本通商产业(MITI)、联合国工业发展组织(UNIDO)、日本节能中心(ECCJ)主办，国家经贸委、机械部、化工部、中国节能协会办的中日铸造工业节能研讨会及中日橡胶工业节能研讨会分别于1998年2月12日和13日在京举行。

联合国工发组织的B. Sugavanam先生、Hassan Nazemi先生、日本节能中心川口友纪枝女士、日本铸造专家官崎义久先生、日本橡胶专家出井宏先生，国家经贸委资源司、机械部生产司、化工部生产协调司和中国节能协会的有关领导和部分企业的代表出席了会议。

国家经贸委资源司左立明司长致开幕词。左司长指出：编制节能技术指南，对交流、推广节能先进技术，节约能源，保护环境具有重要意义，我们将给予积极支持。为促进我国节能工作的发展，加强国际间的交流与合作，引进国外先进的技术和管理方法是非常必要和重要的。召开研讨会是一种很好的交流方式。另外，日本在节能立法方面有很多成功经验，值得我们学习和借鉴，左司长还就我国今年的节能工作作了简要介绍。他说，我国能源消耗高、浪费大、污染重的局面并没有根本改变，同发达国家相比还有很大差距，能耗物耗占企业成本比重很大，企业投入高产出低，结构调整任务很重，节能潜力巨大，我国今年节能工作的重点就是宣贯《节能法》，并作好配套法规的建设。

please fax this paper to: - Mr. HASAN NAZEMI (UNIDO Viena)
- Mr. TANABE (ECCJ) Japan; Fax No: 81-3-5543-3021

OUR SEMINAR IN HANOI, ON 25-26/02/1998.

Tiết kiệm năng lượng trong công nghiệp Đúc và Cao su

LTS: Từ năm 1990 đến nay, tổ chức Phát triển Công nghiệp Liên hợp quốc (UNIDO) đã trợ giúp về mặt kỹ thuật cho các nước đang phát triển trong lĩnh vực quản lý và sử dụng hợp lý các dạng năng lượng trong các ngành: Gang thép, Dệt, Giấy, Sành sứ, Thuỷ tinh, Xi măng, Nhựa ở các nước Malaixia, Inđônêxia, Philippin, Thái Lan, Sri Lanca, Bănglađét, Ấn Độ - Pakistan và năm 1997 là Trung Quốc và Việt Nam. Ngày 20/9/1997, thứ trưởng Lê Quốc Khánh cùng Ông Mikael Brenning, Giám đốc UNIDO Việt Nam đã ký kết văn kiện dự án mang tên: "Chương trình sử dụng hợp lý các công nghệ tiết kiệm năng lượng trong công nghiệp Đúc và Cao su - ở Trung Quốc và Việt Nam". Trong khuôn khổ của dự án, hội thảo đã được tiến hành trong hai ngày 25-26/02/1998 tại Hà Nội. Dưới đây chúng tôi xin trích đăng bài phát biểu khai mạc hội thảo của thứ trưởng Bộ Công nghiệp Lê Quốc Khánh.

Ở các nước đang phát triển nói chung và ở Việt Nam nói riêng, việc sử dụng năng lượng chưa đem lại hiệu quả cao do các trang thiết bị trong công nghệ còn lạc hậu, năng suất lao động thấp; Tổ chức sản xuất còn nhiều bất cập và kết quả là năng lượng sử dụng nhiều nhưng đem lại giá trị kinh tế thấp, kéo theo sự phát thải nhiều loại khí nhà kính làm ô nhiễm môi trường sinh thái.

Trước thực tế đó, từ nhiều năm nay tổ chức Phát triển Công nghiệp Liên hợp quốc (UNIDO) đã giúp đỡ các nước đang phát triển, trợ giúp về mặt kỹ thuật trong lĩnh vực quản lý và sử dụng năng lượng thuộc các ngành: Gang Thép, Dệt, Giấy, Thuỷ tinh, Cao su ở nhiều nước năm nay là Trung quốc và Việt Nam với dự án mang tên: "Chương trình sử dụng hợp lý các công nghệ tiết kiệm năng lượng trong công nghiệp Đúc và Cao su ở Trung Quốc và Việt Nam". Dự án mang mã số: US/RAS/95/048.

Để có thể đạt được mục tiêu phát triển công nghiệp trong sự bền vững về môi trường, UNIDO đang tập trung nỗ lực giúp các nước đang phát triển quản lý năng lượng tổng thể kèm theo các dự án tiết kiệm năng lượng ở các hộ sản xuất tiêu tốn nhiều năng lượng. Trong lĩnh vực này, Nhật Bản là một trong những nước có được chỉ số hiệu quả sử dụng năng lượng trên 1 đơn vị GNP rất cao; Đi đầu trong lĩnh vực này là Trung tâm Tiết kiệm Năng lượng Nhật Bản (ECCJ) đã được UNIDO lựa chọn là đối tác chính cho dự án này. Trong quá trình triển khai dự án, các chuyên gia của ECCJ đã phối hợp chặt chẽ với các chuyên gia của Bộ Công nghiệp, đi sâu vào thực tế sản xuất ở một số cơ sở thuộc các lĩnh vực đúc và cao su nhằm phát hiện những tồn tại trong việc quản lý và sử dụng năng lượng, đưa ra những giải pháp hữu hiệu giúp các đơn vị sản xuất tiết kiệm năng lượng, hạ giá thành sản phẩm, tăng sức cạnh tranh cho hàng nội địa và giảm tối thiểu ô nhiễm môi trường.

Nhân dịp này, cho phép tôi thay mặt Bộ Công nghiệp và Chính phủ Việt Nam cảm ơn sự quan tâm giúp đỡ của tổ chức UNIDO cùng sự tận tình phối hợp chặt chẽ của các chuyên gia thuộc Trung tâm Tiết kiệm Năng lượng Nhật Bản và các chuyên gia Việt Nam.

Tôi hy vọng rằng, thông qua hội thảo này, các cơ sở sản xuất trong lĩnh vực đúc và cao su Việt Nam sẽ học hỏi, trao đổi được nhiều kinh nghiệm trong lĩnh vực quản lý và sử dụng năng lượng; đồng thời phổ biến, nhân rộng ra các ngành, các lĩnh vực khác./

Appendix 5. Seminar Pamphlet

Seminar on Energy Conservation
in
Rubber and Iron Casting Industries

Sponsored by
United Nations Industrial Development Organization (UNIDO)
&
Ministry of International Trade and Industry, Japan
Organized by
The Energy Conservation Center, Japan
Hosted by
State Economic and Trade Commission
12 -13 February 1997
Beijing, China

Introduction

Energy conservation aims at producing increased output with same energy inputs and promoting economic efficiency by improving the productivity and competitiveness of energy consuming enterprises.

In the developing countries, Energy Conservation can serve as an excellent vehicle for promoting industrial sector development by decreasing both the growing shortages of power supply and capital constrain of building new generating capacity.

This seminar on " Energy Conservation in Rubber and Iron casting Industries " has been hosted by State Economic and Trade Commission and organized by Energy Conservation Center, Japan, with assistance from United Nations Industrial Development Organization.

Seminar object

To promote energy conservation and accelerate technology transfer in rubber and iron casting industries through lecture discussion supplemented with reference manuals.

12 February 1997

Seminar Agenda

Energy Conservation in Iron Casting Industry

sponsored by
United Nations Industrial Development Organization
and
Ministry of International Trade and Industry

Hosted by
State Economic and Trade Commission

Organized by
The Energy Conservation Center, Japan

8:30- 9:00 Registration
9:00- 9:30 Opening Ceremony
9:00-9:10 Address by Chinese VIP
  * *Mr. Zuo Liming*, Vice-Director,
  Conservation and Integrated Utilization
  State Economic & Trading Commission (SETC)
9:10-9:20 Address by Japanese VIP
  * *Mr. Tomozou Morino*, Director, Representative Office,
  Japan External Trade Organization
9:20-9:35 Address by UNIDO
  * *Dr. B.Sugavanam*
  Country Director, China
  United Nations Industrial Development Organization(UNIDO)
  * *Mr.Hassan Nazemi*, Environment & Energy Branch
  Industrial Sector & Environment Division, (UNIDO)
9:35-9:40 Address by ECCJ
  * *Mrs. Yukie Kawaguchi*, Manger
  International Cooperation Dept.
  The Energy Conservation Center, Japan(ECCJ)
9:40-10:10 Energy Conservation in Japan
10:10-10:30 Coffee Break
10:30-12:00 Energy Conservation in Iron Casting Industry
  * *Mr. Yoshihisa Miyazaki*, ECCJ
12:00-13:30 Lunch
13:30-15:00 Energy Conservation in Iron Casting Industry
15:00-15:30 Coffee Break
15:30-16:20 Q & A
16:20-16:30 Closing
  Address by Chinese VIP
  * *Mr. Zuo Liming*
  Address by UNIDO
  * *Dr. Sugavanam*

13 February 1997

Seminar Agenda
Energy Conservation in Rubber Industry

sponsored by
United Nations Industrial Development Organization
and
Ministry of International Trade and Industry

Hosted by
State Economic and Trade Commission

Organized by
The Energy Conservation Center, Japan

8:30- 9:00 Registration

9:00- 9:10 Address by Chinese VIP
Chemical Industrial Dept.

9:10- 9:15 Address by UNIDO
* *Mr.Hassan Nazemi,* Environment & Energy Branch
Industrial Sector & Environment Division,
United Nations Industrial development Organization(UNIDO)

9:10-10:00 Energy Conservation in China

10:00-10:30 Coffee Break

10:30-12:00 Energy Conservation in Rubber Industry
* *Mr. Hiroshi Idei,* ECCJ

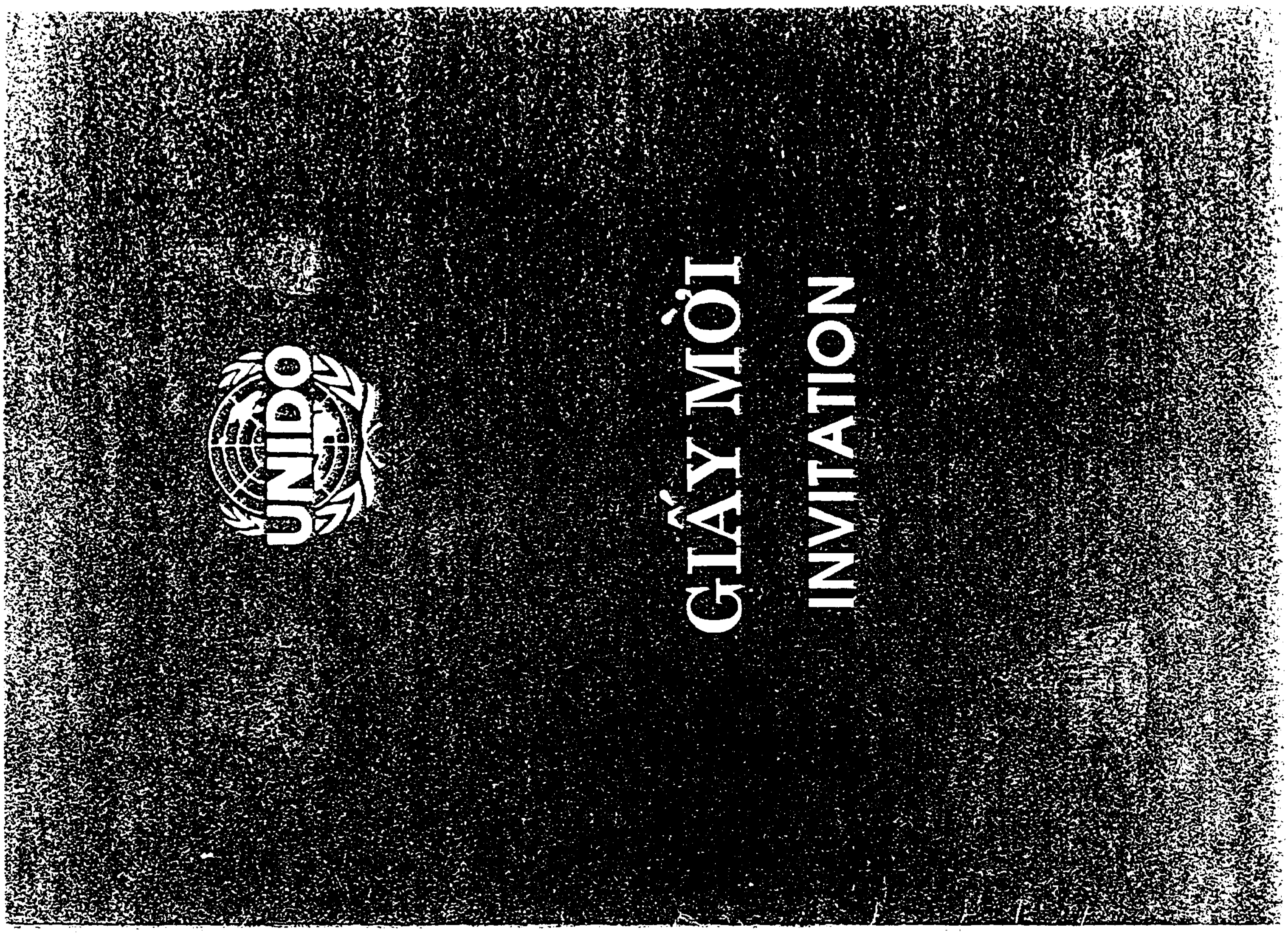
12:00-13:30 Lunch

13:30-15:00 Energy Conservation in Rubber Industry

15:00-15:30 Coffee Break

15:30-16:20 Q & A

16:20-16:30 Closing Ceremony
Address by Chines VIP
Chemical Industrial Dept.
Address by UNIDO
* *Mr.Hassan Nazemi*


UNIDO
GIẤY MỜI
INVITATION

BỘ CÔNG NGHIỆP
VIỆT NAM

TỔ CHỨC PHÁT TRIỂN CÔNG NGHIỆP
LIÊN HIỆP QUỐC & TRUNG TÂM
TIẾT KIỆM NĂNG LƯỢNG NHẬT BẢN

GIẤY MỜI

Trân trọng kính mời Ông/Bà ....

Tới dự Hội thảo về "Tiết kiệm năng lượng trong sản xuất Đúc và Cao su" thuộc Dự án US/RAS/95/48.

Thời gian : 08h00 ngày 25 và 26 tháng 02 năm 1998
(Ngày 25/02/1998 : về lĩnh vực Đúc;
Ngày 26/02/1998 : về lĩnh vực Cao su).

Địa điểm : Khách sạn **Green Park,**
48 Trần Nhân Tông, Hà Nội.

Địa chỉ liên hệ :

Ông Chu Đức Khải,
Vụ Quản lý Công nghệ và Chất lượng sản phẩm,
Bộ Công nghiệp - 54 Hai Bà Trưng, Hà Nội.
ĐT: (04)8258311/436
Fax: (04)8265303.

MINISTRY OF INDUSTRY
VIETNAM

UNITED NATIONAL INDUSTRIAL
DEVELOPMENT ORGANIZATION (UNIDO)
and
THE ENERGY CONSERVATION CENTER
JAPAN (ECCJ)

INVITATION

To Mr/Mrs/Mss

Attending the Seminar on "Energy convervation in the fields of Iron casting and Rubber Industry", Project No US/RAS/95/48.

Time: 08h00, Feb. 25th and 26th, 1998
(Feb. 25th, 1998 on Iron casting field,
Feb. 26th, 1998 on Rubber production field).

Place: GREEN PARK HOTEL,
48 Tran Nhan Tong Str., Hanoi.

Contact person:

Mr. Chu Duc Khai,
Dept. for Technological and Product's quality Management,
Minisrty of Industry - 54 Hai Ba Trung Str., Hanoi.
Tel. (04)8258311/Ext.436
Fax. (04)8265303

CHƯƠNG TRÌNH HỘI THẢO

(Ngày 25/02/1998 về lĩnh vực sản xuất Đúc)

08.00	Đăng ký Đại biểu
08.30	Giới thiệu Đại biểu và Chương trình Hội thảo
08.40	Khai mạc Hội thảo, Ông Lê Quốc Khánh, Thứ trưởng Bộ Công nghiệp
08.50	Phát biểu của Đại diện UNIDO
09.00	Phát biểu của Đại diện Sứ quán Nhật Bản
09.10	Phát biểu của ECCJ (Ông KAZUKI TANABE)
09.20	Tiết kiệm năng lượng trong lĩnh vực Đúc kim loại Ông YOSHIHISA MYAZAKI
10.30	Giải lao
10.45	Tiếp tục
11.45	Câu hỏi và trả lời
12.15	Kết thúc Hội thảo (Vụ Quản lý Công nghệ và chất lượng sản phẩm)
12.30	Ăn trưa

Buổi chiều: Trao đổi, thảo luận với các cơ sở có yêu cầu.

SEMINAR PROGRAMME

(Date: Feb. 25th, 1998 on Iron casting field)

08.00	Participants registration
08.30	Guests introduction and programme
08.40	Seminar opening speech by Mr. LE QUOC KHANH Vice Minister of Ministry of Industry
08.50	UNIDO's speech by Mr/Mrs/Mss ...
09.00	Japanese Embassy greeting speech
09.10	ECCJ's speech by Mr. KAZUKI TANABE
09.20	Energy conservation in the field of Iron casting by Mr. YOSHIHISA MYAZAKI
10.30	Cofee/Tea break
10.45	Continue
11.45	Answer and question
12.15	Seminar's conclusion by Department for Technological and Product's quality Management
12.30	Lunch

Afternoon Section: Disscusion with Institute/Plant if there are requirements.

CHƯƠNG TRÌNH HỘI THẢO

(Ngày 26/02/1998 về lĩnh vực sản xuất Cao su)

08.00	Đăng ký Đại biểu
08.30	Giới thiệu Đại biểu và Chương trình Hội thảo
08.40	Khai mạc Hội thảo, Ông Lê Quốc Khánh, Thứ trưởng Bộ Công nghiệp
08.50	Phát biểu của Đại diện UNIDO
09.00	Phát biểu của Đại diện Sứ quán Nhật Bản
09.10	Phát biểu của ECCJ (Ông KAZUKI TANABE)
09.20	Tiết kiệm năng lượng trong lĩnh vực sản xuất Cao su Ông HIROSHI IDEI
10.30	Giải lao
10.45	Tiếp tục
11.45	Câu hỏi và trả lời
12.15	Kết thúc Hội thảo (Vụ Quản lý Công nghệ và chất lượng sản phẩm)
12.30	Ăn trưa

Buổi chiều: Trao đổi, thảo luận với các cơ sở có yêu cầu.

SEMINAR PROGRAMME

(Date: Feb. 26th, 1998 on Rubber production field)

08.00	Participants registration
08.30	Guests introduction and programme
08.40	Seminar opening speech by Mr. LE QUOC KHANH Vice Minister of Ministry of Industry
08.50	UNIDO's speech by Mr/Mrs/Mss ...
09.00	Japanese Embassy greeting speech
09.10	ECCJ's speech by Mr. KAZUKI TANABE
09.20	Energy conservation in the field of Rubber production by Mr.HIROSHI IDEI
10.30	Cofee/Tea break
10.45	Continue
11.45	Answer and question
12.15	Seminar's conclusion by Department for Technological and Product's quality Management
12.30	Lunch

Afternoon Section: Disscusion with Institute/Plant if there are requirements.

Appendix 6. Terms of Reference for Subcontractor

RATIONAL USE OF ENERGY IN RUBBER AND IRON CASTING INDUSTRIES IN CHINA AND VIET NAM

TERMS OF REFERENCE FOR SUBCONTRACTOR

I. PROJECT OBJECTIVE

To increase the awareness and knowledge of government officials and industrial users on appropriate energy-saving technologies in rubber and iron casting industries in China and Viet Nam.

II. BACKGROUND INFORMATION

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

In December 1983, UNIDO organized a regional meeting on energy consumption in small and medium industries and an expert group meeting on exchange of experience on energy conservation in small and medium industries for Asian countries. During the meetings, it was revealed by some countries that for several energy-intensive industries (e.g. iron and steel, pulp and paper, glass, cement and ceramic, and chemical industries), a saving of up to 10% on the energy consumption could be achieved through basic house-keeping improvements in terms of auditing and energy management. Larger savings could be achieved (up to 30% in a period of about 2-3 years) through the application of energy-saving technologies by retrofitting, installation of control mechanisms and simple process changes.

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

In 1990, UNIDO started a new programma on the rational use of energy saving technologies and, in 1991, a first project - US/RAS/90/075 "Programma for Rational Use of Energy in Iron and Steel and Textile Industries" - was approved and financed by the Government of Japan. Surveys and seminars on the application of appropriate technologies for the effective use of energy were conducted by Japanese and UNIDO specialists in Malaysia and Indonesia. As a result of this program, manuals on energy saving technologies for iron and steel and textile industries were prepared. The manuals, currently available in English, will be translated to French and Spanish in order to be disseminated to other developing countries in Asia, Africa and Latin America.

The success of this promotional activity prompted UNIDO to request the support of the Government of Japan to continue the programma. Consequently, a second project was approved for the rational use of energy saving technologies in pulp and paper and glass industries in the Philippines and Thailand, where many of the above-mentioned industries were found, and human resources as well as technological levels were adequate for introducing energy conservation technologies. Also, strong counterpart institutions were available. Surveys were carried out and seminars and demonstrations were completed in September 1993. Also, handy manuals for energy saving technologies in the pulp and paper and glass industries were prepared and widely disseminated.

A third project in this series was held in 1994, covering the ceramic and cement industries in Sri Lanka and Bangladesh.

The forth project in this series was held in 1995, covering the food processing and plastic transformation industries in India and Pakistan.

After a UNIDO-Japanese joint assessment of the results and the positive effects that this programma had generated in developing countries, it was agreed to propose a new project for the rational use of energy saving technologies in rubber and iron casting industries in China and Viet Nam. Although industries in these sectors are quite established in both countries, still some aspects of conservation of energy are neglected, much energy is wasted and, therefore, it is necessary to assist them to utilize appropriate techniques in order to improve energy efficiency.

Under this programma, China and Viet Nam as well as other developing countries will benefit at the end of the project from UNIDO's experience in promoting and applying energy-saving technologies in rubber and iron casting industries, with a multiplier effect in the industrial and technology process development as well as in the environment conservation in these countries.

III. SCOPE OF CONTRACTING SERVICES

a) As soon as possible following award of the contract, the subcontractor's team leader will visit Vienna for a two-day briefing by concerned technical staff in UNIDO's Industrial Sectors and Environment Division, and also by UNIDO's Purchase and Contracts Service Section.

b) The team leader will then proceed to the field to join his/her colleagues (see paragraph g) where the team will undertake a survey of rubber and iron casting industries to identify needs in respect of energy conservation and energy savings technologies. The survey will be based on plant visits and discussions with the national counterpart and specialized institutions identified in Annex I attached herewith. Plants should be selected following consultation with these institutions. It is expected that the surveys will require 3 weeks of field work.

The surveys should include detailed analyses of the energy consumption of installed process equipment. While executing the surveys the subcontractor's team will compile a list of technical issues concerning energy conservation and energy saving technologies in the industries of concern in China and Viet Nam. These issues (in the form of questions to which the national counterparts have requested answers) should be addressed prior to the team's departure from each country.

c) Upon completion of field work and the team's return to Japan, a date will be set for UNIDO technical staff to visit the subcontractor's team in Japan for detailed discussion of the team's findings and to reach agreement with the contractor on the content of the manuals. The manuals should include information on and discussion of energy conservation techniques and energy-efficient technologies reflecting the team's findings/observations during the field surveys. Subjects to be covered and depth of coverage will be a matter for discussion during the meetings at the subcontractor's HQ.

d) In close co-operation with the national counterparts, a two-day seminar will be held in each country for top executives, middle level managers, government officials, engineers and technicians, and people responsible for the production process and policies regarding energy saving aspects in the concerned industries of the two countries as well as other developing countries in Asia. The seminar lecturers will come from the subcontracted organization, from the counterparts in China and Viet Nam as well as from UNIDO HQ.

e) UNIDO expects the subcontractor to prepare 600 copies of each manual (in English) on energy conservation/saving technologies in rubber and iron casting industries, for the use of technical operators in improving energy efficiency practices at the plant level in developing countries. The two manuals will address potential energy conservation measures according to the following framework.

Manual for Rubber Industry (Tires)

50% of the thermal energy used in manufacturing of tires is consumed in the curing process. A significant portion of this thermal energy is lost through radiation from equipment and pipelines and by discharge to atmosphere and waste water. There is a great potential to reduce energy consumption in manufacturing of tires in general and in curing process in particular. Effective energy-saving measures that can be taken in various process components should be fully addressed. These measures include, but not limited to, the following :

- Repair and strengthening of heat insulation for curing press and pipelines
- Check and prevention of steam and air leakage
- Maintenance and inspection of steam traps
- Integration and rearrangement of steam lines
- Shortening of machine open-shelving time
- Recovery and use of waste heat
- Reduction of temperature difference between upper and lower press molds
- Reduction of dispersion of proportioning rubber blow point (shortening of curing time)
- Review of mold blow method
- Review of water cooling and vacuum suction
- Maintenance and control of the room temperature for the winter season

For the following melting furnaces, applicable energy-saving measures will be introduced and discussed. These measures will include, but not limited to those outlined below.

Electric arc furnace

a. Decrease of the heat input

1. Substitution of heat input
   - o auxiliary combustion of oil
   - o oxygen injection
   - o preheating of scraps
2. Utilization of waste heat
   - o preheating of ladle bricks
   - o utilization of hot returned scraps
3. Lowering molten steel temperature
   - o increasing of ladle bricks temperature
   - o prevention of heat release by ladle lid

b. Reduction of heat loss

1. Improvement of facilities
   - o increasing furnace capacity
   - o adoption of high power system
   - o improvement of automatic electrode controller
   - o reduction of resistance of secondary conductor and electrode
   - o reduction of openings on furnace body
   - o insulation
2. Improvement of operation
   - o removal of impurities from scraps
   - o quick-charging of scraps and other raw material
   - o optimizing power input
   - o speeding up analysis of molten steel
   - o shortening maintenance time
   - o preventing breakage of electrodes
   - o reducing waiting time for equipment (crane etc.)
   - o improving efficiency of dust collectors

c. Improvement of product yield

- o selecting good quality raw material
- o reducing casting defects
- o decreasing of residual molten metal

d. Utilization of waste heat

- o preheating scarps
- o producing hot water for heating, air conditioning and boiler feed water

Induction Furnace

a. Decrease of heat input

1. Lowering molten steel temperature
   - o preheating of ladle brick
   - o prevention of heat release by ladle lid
   - o avoiding overheating

b. Reduction of heat loss

1. Improvement of facilities
   - o selection of optimum frequency
   - o reduction of resistance of cable and bus bar
   - o closing gap of cover
   - o improvement of power factor
   - o increasing efficiency of frequency convertor
2. Improvement of operation
   - o removing impurities of charging scrap
   - o dense charging of scrap
   - o optimum size of starting block
   - o shortening idle time

Cupola

a. Design of furnace profile

b. Reduction of heat loss

1. Improvement of operation
   - o selection of optimum blast volume
   - o dehumidification of blast air
   - o optimum grain size of cokes
   - o moisture control of cokes and other material
2. Improvement of facility
   - o two layers blowing
   - o waste heat recovery from cooling water of furnace body (water-cooled cupola)

The manuals will demonstrate innovative energy conservation/saving technologies developed in Japan and adapted to the conditions and requirements of the rubber and iron casting industries in developing countries. All analysis and recommendations given are to be based on existing and available technological solutions and resources. The suppliers of technologies and sources of information should be clearly identified. 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 the information available in Japan will be reviewed by the subcontractor and incorporated into the proposed technical manuals.

The two technical manuals will be prepared in English. Three copies of the draft manuals will be submitted to UNIDO by the subcontractor for comments before final printing. 600 copies of each of the two technical manuals will be required to be forwarded to UNIDO HQ for distribution in developing countries.

f) A final report which summarizes all work done including the outputs of the seminars held in China and Viet Nam 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. Three 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.

g) The subcontractor will provide the following personnel to carry out the scheduled project activities:

- Three experts (a team leader, a rubber expert and an iron casting expert) for 3 weeks to implement plant surveys in China and Viet Nam including supervision of local counterparts.

- A minimum of two specialized technical experts for 2 weeks to organize seminars, hold lectures, and disseminate the technical manuals in China and Viet Nam. Further, the experts will carry out a survey to assess the implementation procedure and the impact of the project.

As a part the activities during the seminars, national experiences and expertise of the two countries on the application of energy conservation/saving technologies shall be presented and discussed.

h) The subcontractor will be fully responsible for the provision of all necessary facilities and services to conduct the seminars on schedule in China and Viet Nam (2 days each in each country). In each country, about 50 participants are expected each day.

Specifically, the following facilities and services will be provided by the contractor:

- seminar registration desks;
- Simultaneous interpretation services (English, Japanese and national language);
- Microphones;
- Audio-visual equipment (projector, movie screen, video-tape players, tape recorder, etc.);
- Podium for lectures; and
- Miscellaneous services.

The national counterparts in China and Viet Nam shall assist the subcontractor in the provision of the above-mentioned facilities and services, but at no cost to them.

i) The subcontracting organization shall plan the activities falling under the scope of the subcontracting service in accordance with the tentative work plan attached as annex C.

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.

National Counterpart Organizations

China	Viet Nam
State Economic and Trade Commission Department of Resource Saving and Comprehensive Utilization of Energy	Ministry of Planning and Investment Industry Department

Note

Specialized institutions to be consulted in China and Viet Nam for the implementation of this project are identified above.

Appendix 7. Handy Manual

" IRON CASTING INDUSTRY "
" RUBBER INDUSTRY "

HANDY MANUAL

PLASTIC FORMING INDUSTRY

Output of a seminar on Energy Conservation in Rubber Industry

Sponsored by

United Nations Industrial Development Organization (UNIDO)

and

Ministry of International Trade and Industry (MITI) , Japan

Hosted by

State Economic and Trade Commission
People's Republic of China

Ministry of Industry
Socialist Republic of Viet Nam

Organized by

The Energy Conservation Center (ECC) , Japan

1998

PREFACE

The conservation of energy is an essential step we can all take towards overcoming the mounting problems of the worldwide energy crisis and environmental degradation. Although developing countries and countries with economies in transition are very much interested in addressing the issues related to the inefficient power generation and energy usage in their countries, only a minimum amount of information on the rational use of energy is available to them. Therefore, distributing the available information on modern energy saving techniques and technologies to government and industrial managers, and to engineers and operators at the plant level in these countries is essential.

In December 1983, UNIDO organized a regional meeting on energy consumption and an expert group meeting on energy conservation in small- and medium-scale industries for Asian countries. The outcome of these promotional activities prompted UNIDO to initiate a new regional programme designed to increase the awareness and knowledge of government officials and industrial users on appropriate energy saving processes and technologies. In 1991, the first project, Programme for Rational use of Energy Saving Technologies in Iron and Steel and Textile Industries in Indonesia and Malaysia (US/RAS/90/075), was approved and financed by the Government of Japan.

The successful completion of this project prompted UNIDO to request the financial support of the Government of Japan to carry out similar projects under this programme in other Asian countries. Since 1992, under continuous support of the Government of Japan, three other projects have successfully been completed: Rational Use of Energy Saving Technologies in Pulp and Paper and Glass Industries in the Philippines and Thailand (US/RAS/92/035); Ceramic and Cement Industries in Bangladesh and Sri Lanka (US/RAS/93/039); and Plastic Forming and Food Industries in India and Pakistan (US/RAS/94/044).

This year UNIDO is carrying out the programme in China and Vietnam, targeting two energy intensive industrial sub-sectors: iron casting and rubber industries.

Rubber industry consumes a substantial amount of energy. Excessive use of energy is usually associated with many industrial plants worldwide, and rubber plants are no exception. Enormous potential exists for cost-effective improvements in the existing energy-using equipment. Also, application of good housekeeping measures could result in appreciable savings in energy. Therefore, it is imperative to introduce and distribute information on modern energy-saving techniques and technologies among the parties concerned in government and especially, at plant level, in industries.

To achieve the objectives of this programme, UNIDO has adopted the following strategy.

1. Conduct plant surveys to characterize energy use and to identify measures to improve energy conservation at the plants.

2. Prepare handy manuals on energy management and on applicable energy conservation techniques and technologies.

3. Organize seminars to discuss the content of the handy manuals and the findings of the plant surveys with government officials, representatives of industries, plant managers and engineers.

4. Distribute the handy manuals to other developing countries and countries with economies in transition for their proper use by the targeted industrial sectors.

UNIDO prepared this handy manual for the rubber industry, with the cooperation of experts from the Energy Conservation Center, Japan (ECCJ), on energy saving technologies in the framework of this UNIDO programme. It is designed to provide an overview of the main processes involved in manufacturing of rubber, and to present a concise outline of the applicable energy saving measures.

Appreciation is expressed to the following institutions for their valuable contribution to the successful preparation and publication of this manual:

The State Economic and Trade Commission of the People's Republic of China;
The Ministry of Industry of the Socialist Republic of Viet Nam;
The Ministry of International Trade and Industry of Japan; and
The Energy Conservation Center, Japan.

Contents

Outline of Rubber Industry

Some 500 years ago natural rubber was discovered by Christopher Columbus. Since then, the use of crude rubber has gradually spread in Europe and the U.S., as can be seen in rubber-coated cloth today. With advances in the method of processing rubber as well as in scientific research, Charles Goodyear succeeded in discovering the "heat curing method" in 1839, a process in which crude rubber is heated with sulfur to yield "vulcanized rubber", highly elastic and more resistant to heat than crude rubber. Soon after in England Hancock followed suit. He developed various methods of vulcanization after perceiving the essence of this process. This heralded the start of the modern rubber industry.

During the Industrial Revolution from 1830's through 1840's, bicycles and automobiles were invented along with the opening of railway traffic, and the necessity to meet the needs of the times led to the invention and later to the spread of pneumatic tires.

In 1845 in England, R. W. Thomson tried to develop pneumatic tires for trucks to replace the tires mounted on iron wheels or solid tires prevalent in those days. Later in 1888 in England, Dunlop (J. B. Dunlop) succeeded in developing pneumatic tires for bicycles and tricycles with solid tires. The pneumatic tires invented by Dunlop were adopted in the bicycle race in 1889, and went so far as to be used for automobiles until finally they were standardized around 1905 after various improvements. Later studies for improving durability, comfort of riding, driving force, braking force, and swirling force have brought about drastic changes in shape, structure, and members used of tires, and further in the method of testing tires.

Remarkable progress has also been witnessed in the process of and equipment used in manufacturing pneumatic tires. The manufacture of tires requires the largest equipment in comparison with that of other rubber products, accompanied by the consumption in large quantities of rubber materials, electric power, coal, oil and gas.

After outlining the general process of manufacturing tires, I would like to propose for your consideration my concept and several examples of energy conservation.

1. Tire Manufacturing Processes

The process flow diagram (Fig. 1) represents general tire manufacturing processes, giving the flow of work ranging from the preparation of intermediate products (members) from various raw materials to the completion of tires by a combination of those members, along with the outlines of all the equipment used for respective processes. The processes consist mainly of mix formulation, compounding, molding, vulcanization, and finishing, accompanied further by the processes of manufacturing tire cords and bead wires.

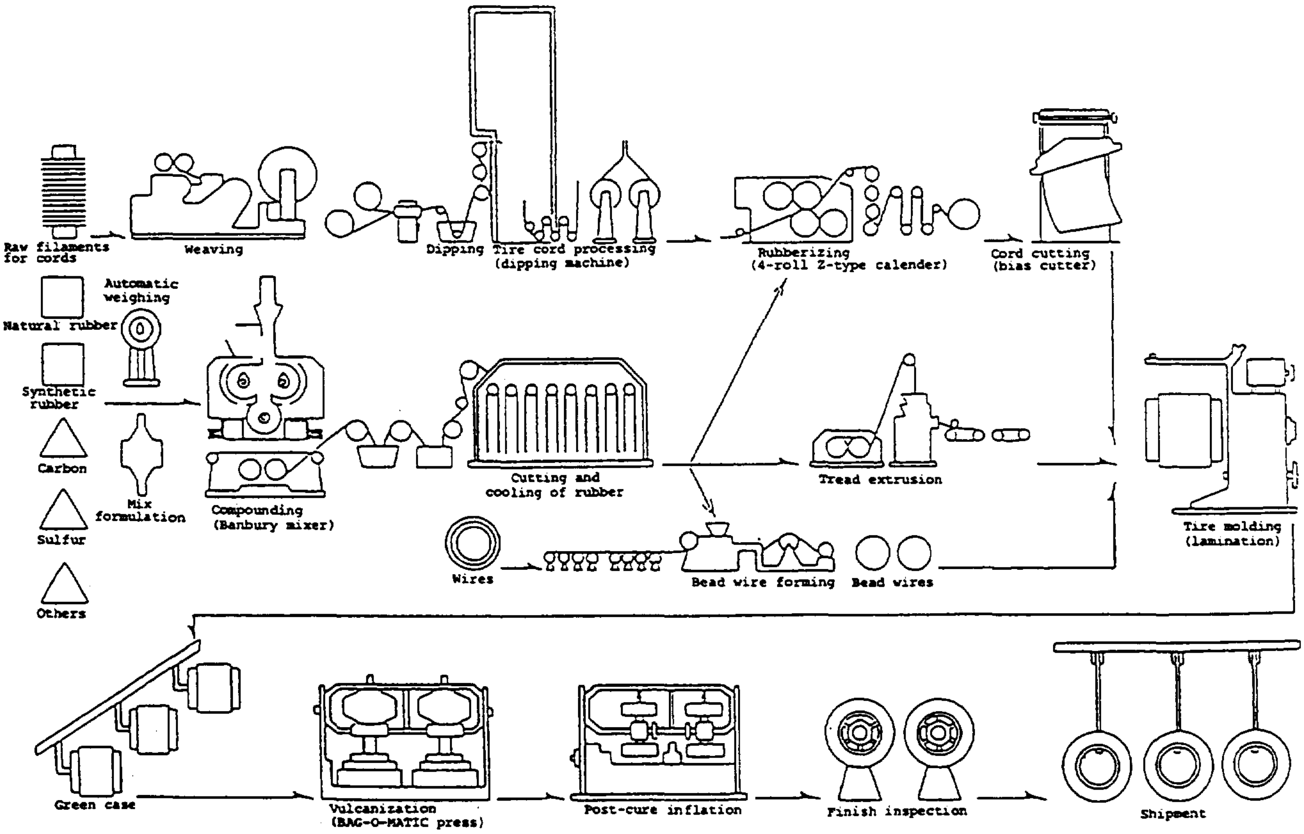


Fig. 1 Tire manufacturing process flow diagram

1.1 Characteristics of Manufacturing Tires

The tire manufacturing processes consist of:

1) preparing intermediate products (members) utilizing the fluidity and plasticity of crude rubber,

2) laminating the members covered with crude rubber utilizing the tackiness of the covering crude rubber,
3) assembling the members to make raw tires, and
4) vulcanizing them at the final stage to produce chemically stable and elastic tires.

Since green rubber is unexpectedly stiff, it is generally sheeted or extruded with a large-capacity motor after it has been softened by heating. The tire manufacturing industry is therefore classified as a large energy consuming industry.

The plasticity of rubber is greatly influenced by the quality of raw material elastomers, the methods of compounding and hysteresis of rubber, and working conditions of respective processes. Tackiness also varies widely depending on the kinds of rubber and the formation of a thin coating on the surface of rubber, called blooming.

The degree of blooming depends largely on the kinds of compounding ingredients, moisture when rubber was compounded, length of time and temperature after compounding, and stimulation by rubbing. In an extreme case, rubber does not adhere at all. It is impossible to eliminate the variance resulting from the fluidity of rubber and accompanying movement of cords even in the process of thermal vulcanization.

The variance in plasticity and tackiness makes it inevitable to largely rely on manual work even today when automation is highly advanced in the molding process in which raw tires are assembled. Given this situation, elimination of variance can contribute a great deal to energy conservation, to say nothing of the improvements in quality and productivity.

1.2 Preparation of Materials

The manufacture of tires begins with preparing materials for rubber compounding, and for pretreatment and subsequent rubber-coating of cords (to wrap them in rubber) so that various raw materials processed can be used for the later processes of making intermediate products (members).

1.2.1 Rubber compounding (mix formulation and compounding)

A variety of raw material elastomers and various compound ingredients are used for tires by mixing and compounding them for use in respective members. In former days, this compounding was carried out with open rolls, and naturally the working site was made terribly dirty due to the scattering of carbon black and other chemicals. Today, intensive mixers, including internal and Banbury mixers, are widely used. This intensive mixer is of enclosed type and computer-controlled so that raw material elastomers, various compounding ingredients and oil are automatically fed and compounded. This has resulted in reducing dirt to a considerable degree. Fig. 2 shows this process schematically.

Since the properties of rubber, uncured and cured, vary greatly depending on various factors as described below, attention has been focused on producing rubber compounds to specifications with a slight variance by computer control. The various factors include the kind, quantity, order and time of feeding, the extent to which ingredients are mixed evenly, compounding time and temperature of raw material elastomers and compounding ingredients.

In this process, high-capacity motors are used. This inevitably involves large power consumption, which accounts usually for 35 to 55 per cent of the total power consumption of the factory. It is common practice to recycle cooling water used in large quantities.

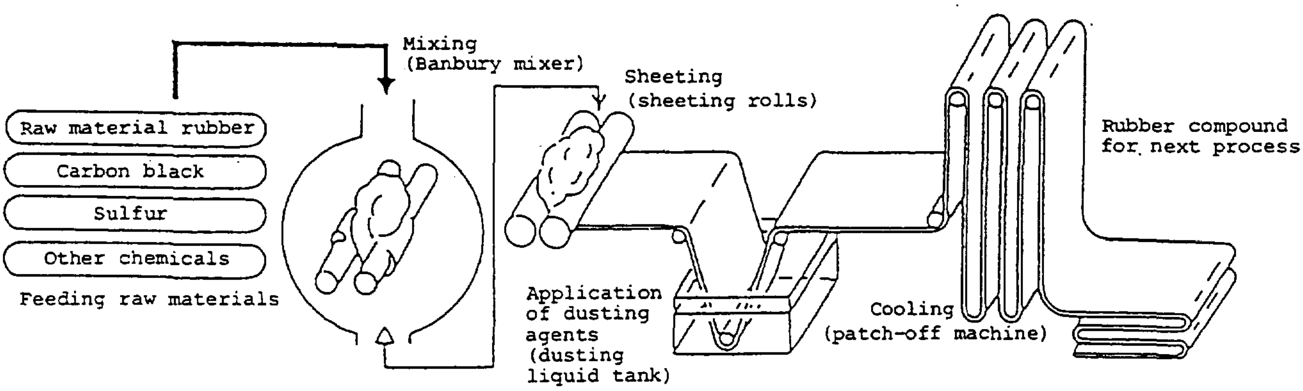


Fig. 2 Diagram of mixing and compounding processes

1.2.2 Pretreatment of cords

Pretreatment of tire cords and canvas is a very important process aiming not only at processing fibrous materials and rubber for good adhesion, but also at modifying the properties of fibers, particularly synthetic fibers, including nylon, polyester and rayon, into ones fit for tire cords. It is a process in which cords are dipped in adhesives, and, at the same time, are subjected to great tension at high temperature. This makes them more difficult to stretch out and thermally stable and are in this form best suited for tire cords. This process requires large equipment in which dipping and drying can be carried out simultaneously.

1.2.3 Calendering

Calendering, also called rolling, is a process in which the coating operation is carried out by covering treated textile fabric or steel cords with thin rubber layers on both sides so that materials to be used for sandwiched plies and belts can be made. The quality and thickness of rubber layers depends on respective applications.

The important point in this process lies in the accuracy of thickness in both directions of length and width. Inaccurate thickness leads to the poor performance of tires and, in addition, to vibration due to increased imbalance. Accuracy is therefore required to 1/100 mm. A calender with three or four rolls is generally used. The temperature of rolls and gauges are computer-controlled. Figs 3 and 4 show respectively a schematic drawing for textile fabric cords and a conceptual drawing for steel cords.

In addition to its use for coating cords and canvas, a calender is also used for preparing various kinds of rubber sheets, squeegees (belt-like rubber sheets for reinforcing plies), and strips (strings), and is one of the important pieces of equipment at the rubber factory. It also consumes a high amount electric power.

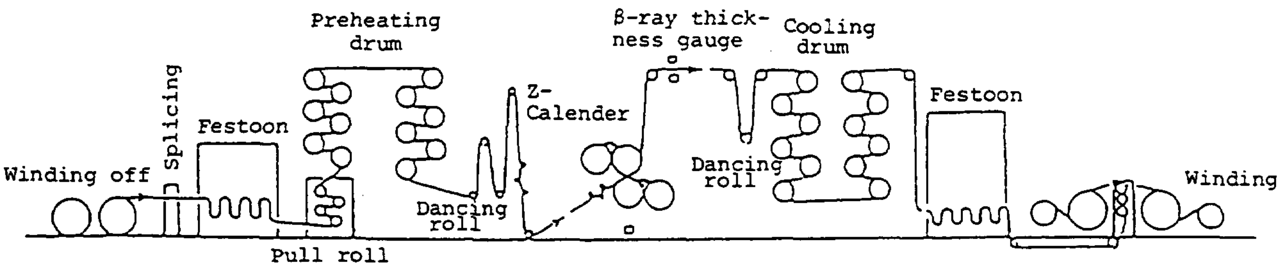


Fig. 3 Calendering process flowsheet

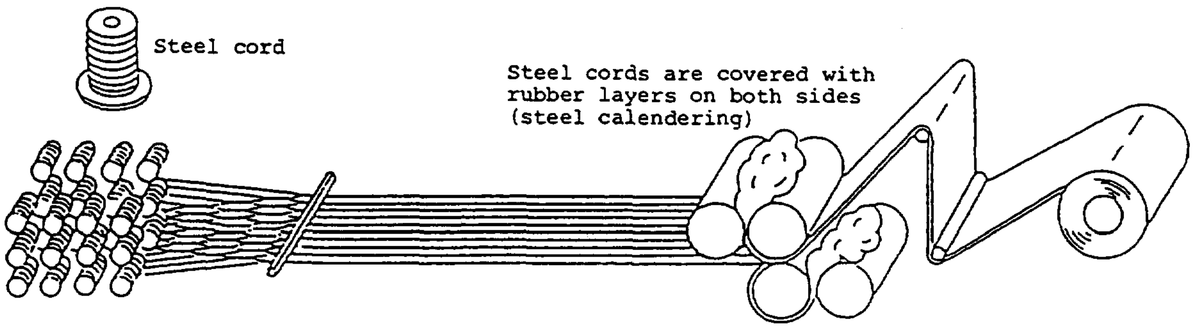


Fig. 4 Steel cord calendering process flowsheet

1.3 Preparation of Members

In the later sections on the processes of preparing necessary members according to respective sizes of various tires, the forming of a bead, cutting of rubberized cords including plies and belts, and extrusion of a tread and a sidewall will be described.

1.3.1 Rubber coated cord cutting

The operation is called "cutting", in which rubber coated cords and canvas are cut to the angle and width according to respective applications of tires.

The machine used is called "a bias cutter", classified into two types: one is a cutter as used for press-cutting paper or thin steel sheets, while the other is a ring cutter that runs at high speed along the beam used for checking the cutter and cords. Two types are available for cutting devices: one is a vertical one with which coated materials, wound off the roll and suspended vertically, are cut after they have been held down, while the other is a horizontal one with which coated materials, wound off the roll onto the conveyor for horizontal lamination, are cut while they are held down. Since the width and the angle of cutting need to be accurate, a horizontal type is more widely used. Fig. 5 shows the conceptual drawing of a horizontal bias cutter.

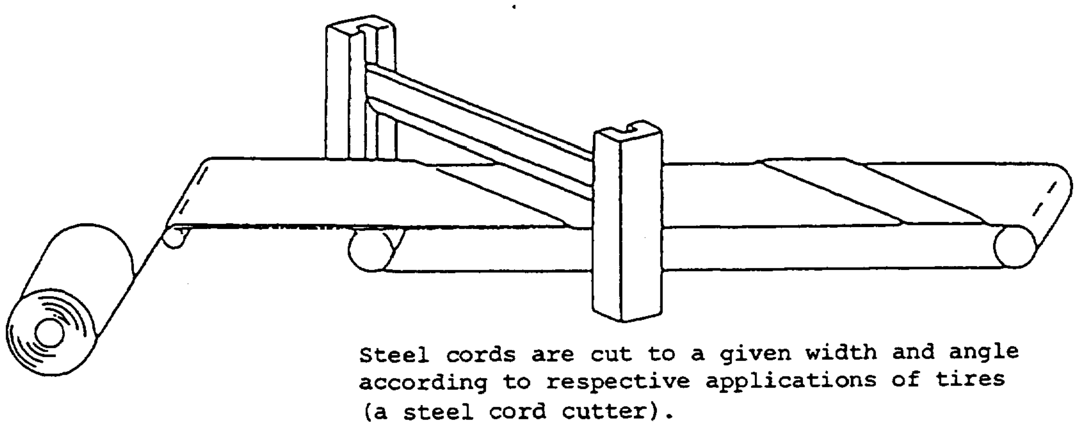


Fig. 5 Process flowsheet of cutting steel cords

1.3.2 Extrusion of Treads and other Moldings

An extruder is used for preparing rubber members with definite cross-sections, such as treads and sidewalls. Fig. 6 shows a schematic drawing of this operation. Rubber for treads, compounded in the Banbury mixer, is softened by kneading through the hot rolls, fed to the extruder, forced through the tread die with a given cross-section, and cut to a desired length after cooling.

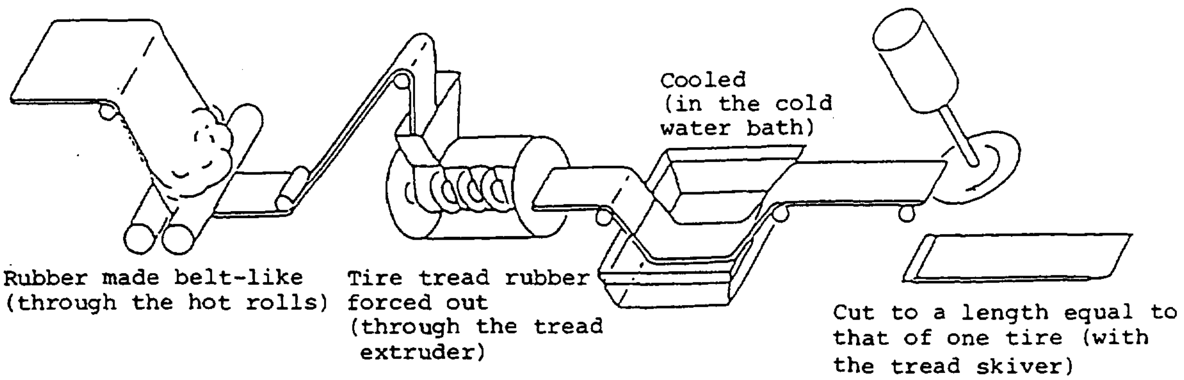


Fig. 6 Tread extrusion process flowsheet

The process of extruding treads is one of the most important ones in the manufacture of tires, the uniformity of which is strictly required, because the tread, accounting for nearly half of the total weight of a tire, tends to cause trouble when imbalanced. It is therefore important that the extruded and cooled tread is cut to the correct and uniform length, thickness, shape and weight.

Various extruders are used for tread extrusion depending on respective discharges, and multi-layer extruders aiming at the simultaneous extrusion of the combination of various kinds of rubbers have come to be used widely in recent years.

The multi-layer extruder extrudes the compound, fed from more than two extruders in respective quantities required, to a desired shape. Two types of extruders are available, hot and cold types, as described earlier. The former requires heating, whereas the latter does not. Electric power is required in large quantity for softening rubber with a screw.

1.3.3 Bead molding

Bead wires, arranged at a given interval and in given number, are rubber coated and extruded to a flat bead, which, in turn, is wound around the core drum, with an inside diameter given according to respective kinds and sizes of tires, by the number of steps required. This is a process most commonly used. Fig. 7 shows a schematic drawing. Usually, thin rubberized fabric tape, called bead covering tape, is wound further with apex rubber attached thereon.

This process is carried out by another equipment.

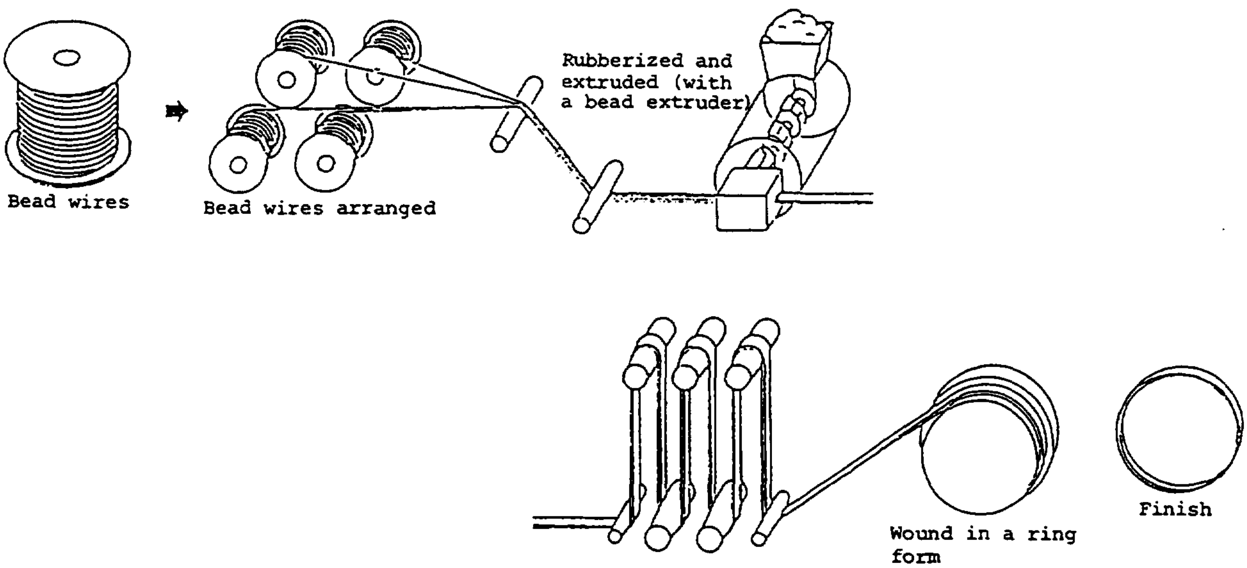


Fig. 7 Bead making process flowsheet

1.4 Manufacture of Green Tires

Green tires are made by the molding process in which various members, prepared through the processes described earlier, are laminated. Two methods are available for molding: one is used for bias tires, and the other for radial tires, each differing in carcass structure.

Fig. 8 shows this process.

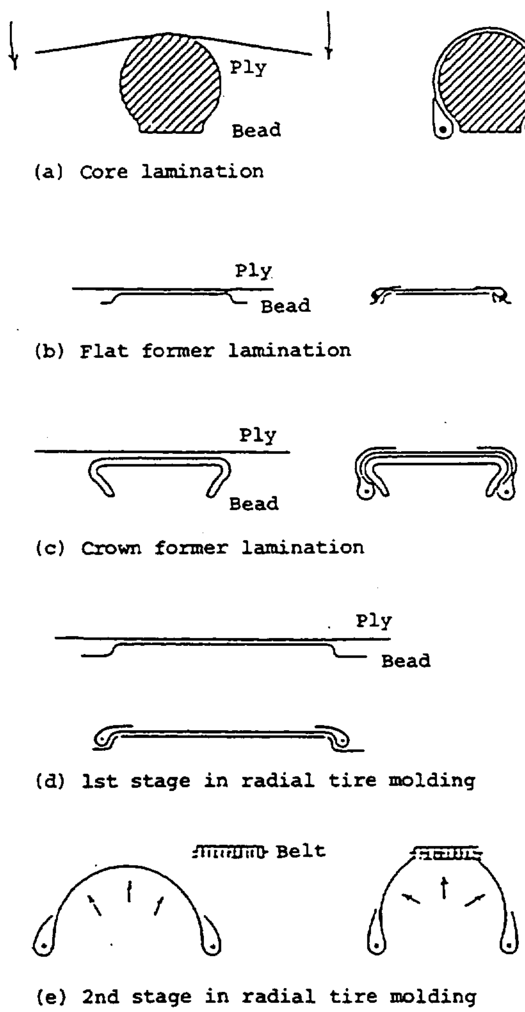


Fig. 8 Conceptual drawing of molding methods

The flat former lamination in Fig. 8 (b) is a method by which all members, including a ply, a bead, a breaker, and a tread, are laminated on a cylindrical former, also called a drum, with a diameter slightly larger than that of a tire rim, to make a cylindrical green tire. A carcass is inflated, a process called shaving, during vulcanization to make a doughnut-shaped tire. Then, the interval between cords widens to lead to a decrease in pressure resistance. The flat lamination is therefore a method of molding tires for low pressure use to be used for small automobiles, light trucks and agricultural machines.

The crown former lamination process in Fig. 8 (c) is a method generally used for molding green tires, for which resistance to high pressure is required, to be used for trucks, buses, construction machinery and aircraft, because in this process the degree of inflating a green tire to a finished one is comparatively low thus enabling the required strength to be secured in addition to the ease of molding a bead part even if the number of plies increases when necessary. In this process, the so-called crown drum is used with a large space for laminating cords within a range allowable for the operation of narrowing plies down toward the bead part.

When the crown drum is used, several plies are pre-laminated in a ring form, called a band, in consideration of the operation of narrowing plies down, and fitted to the drum so that the plies can be narrowed down toward the bead part. Since another machine, called a band builder, is used for making a band, a combination of a molding machine and a band builder is commonly employed. Needless to say, a breaker, a tread, and a sidewall are also laminated in process (c) besides those in the above figure.

When canvas was used for a tire ply, it required much labor in the core lamination in process (a) when molding a tire. A tire was not formed then unless pleats, made from a sidewall through to a bead, were folded. The invention of cords, however, has led to a higher productivity because it has enabled green tires to be made almost cylindrical in shape by molding processes (b) and (c).

On the other hand, in the process of molding a radial tire, in which the belt part is made so as not to extend in the circumferential direction, it is impossible to inflate a tire after it has been molded flatly unlike a bias tire.

It therefore becomes inevitable to apply a belt and a tread after inflating a laminate close to a finished tire in shapes described later. The molding operation is therefore carried out usually in two stages: an inner liner, a carcass ply, a bead assembly, and a sidewall are laminated on the easy-to-operate flat drum in first stage shown in Fig. 8 (d) because those rubber products can be easily shaved. And a belt and a tread are applied after the resulting laminate has been inflated close to a finished tire in size in second stage shown in Fig. 8 (e).

In the tire molding factory, green tires cylindrical in shape are bias tires, laminated on the flat drum, for use under low pressure, while radial tires are close to finish tires in shape. Fig. 9 shows how green tires differ from each other in shape when used for radial and bias tires of passenger cars.

(a) Bias (b) Radial

Fig. 9 Shapes of green tires

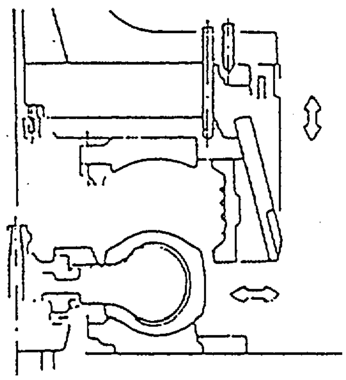
1.5 Vulcanization of Tires

Molded tires are fed to a mold (a metal mold with a tread pattern, a side pattern, a marking, and a trademark carved thereon) of the specified vulcanizer, pressed against the inside of the mold from the inside, and heated simultaneously from both sides, internally and externally, with heating media, such as steam and hot water, so that, after a given period, vulcanization proceeds throughout the entire tire. Thus, a finished tire with a vulcanized rubber structure is elastic and stable.

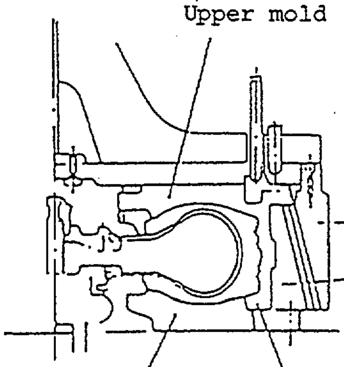
Automatic vulcanizers, such as BAG-O-MATIC® and AUTOFORM®, are widely used. With these machines, the insertion of green tires and the taking out and transfer of cured tires are carried out completely automatically with no one attending. Operators have only to prepare green tires and watch the process.

Since synthetic fibers shrink by nature if left standing when hot, hot tires after vulcanization diminish in size when left standing. A device (a post-cure inflator) is therefore provided, with which bias tires in which synthetic fibers are used are inflated by applying air pressure immediately after vulcanization, and cooled in an inflated state.

Two types of molds are used for molding tires: one is a full mold that splits into upper and lower parts, and mainly used for molding bias tires, while the other is a split mold widely used for molding radial tires. The split mold is one that splits into 6 to 9 segments along its perimeter. Fig. 10 shows conceptual drawings of a vulcanizer and a split mold in use.



(a) When opened



(b) When closed

Fig. 10 Conceptual drawing of a vulcanizer

The process of vulcanization consumes more steam than any other processes for making tires. Since fuel consumption of the factory is greatly influenced by this process, it is very important to devise a method to save energy for this process, which usually accounts for 60 to 90 per cent of the total steam consumption of the factory.

1.6 Finishing of Tires

When finishing tires, a vent hole, drilled right through a metal mold, is used for discharging air from the space between the tire and the mold. Any excess rubber is forced out and forms hair-like vent spew in the vent holes and other shapes of spews at the split parts of upper and lower molds and joint parts between mold segments. These spews should be removed for good appearance. Automatic finishing machines have recently been introduced for this purpose in most of the factories. The finished tires are subjected to 100 per cent inspection including that of appearance (a sensory test by an inspector) for rejection of defective units. Those for use in passenger cars, trucks, buses and aircraft are further subjected to a balancing test to screen unbalanced units. A uniformity machine is also incorporated in the production line for measurement of uniformity of tires for use in passenger cars, trucks and buses.

Supplement:

Names of tire parts

Fig. 11 (a) is a cross-section of the steel-belt radial tubeless tire for passenger cars, and Fig. 11 (b) shows the appearance and the internal structure of both bias and radial tires for better understanding.

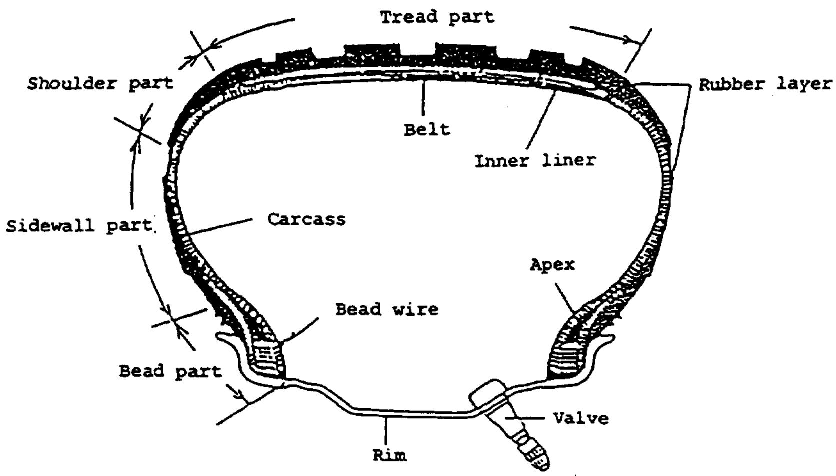
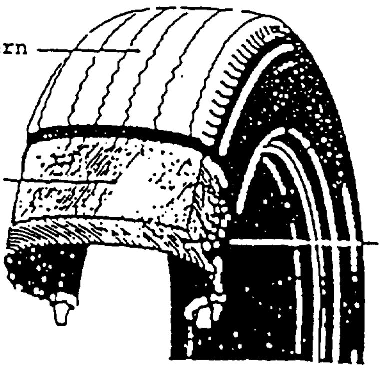


Fig. 11 (a) Cross-section of passenger car radial tire

(a) Bias tire

(b) Steel-belt radial tire



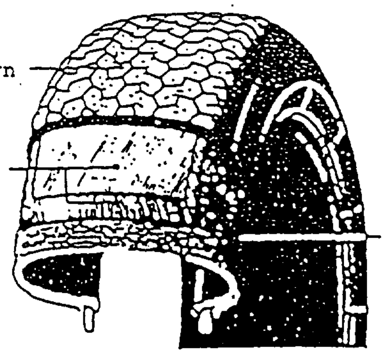


Fig. 11 (b) Structures of bias and radial tires for passenger car

Names of tire parts

Tread: That portion of a rubber layer which makes contact with the road surface. The tread pattern is engraved on the surface so as to give the tire a non-skid property.

Side : A portion between the tread and the bead. The surface rubber layer only of this portion is sometimes called a sidewall.

Bead : A portion made to suit the rim, with a circular assembly of steel wires wrapped with plies.

Shoulder: An interval between the tread part and the side part. The boundary is not definitely defined.

Carcass: A portion constituting the structure of a tire composed mainly of ply and bead parts, including a belt. In some cases, it includes a breaker. Ply is a thin layer of rubberized fabric.

Breaker: One to several layers of textile material inserted between the tread and the carcass of a bias tire to protect the carcass from road shock or from external damage.

Belt : In a radial tire, it is placed in the same position as a breaker, with textile material, durable and hard to stretch out, arranged almost circumferentially around the tire to give a hoop effect.

Interliner: In a tubeless tire, it is a thin butyl rubber layer, made gas tight to hold air pressure, and is used for lining a carcass. In a tire with an inner tube, the tire is lined only with an ordinary rubber layer since the tube itself is made of highly gas tight butyl rubber.

Apex : Apex stands for the uppermost peak of a triangle. It is a hard rubber member with a triangle-shaped cross-section, sometimes added onto bead wires to put the bead part in shape as well as to give rigidity. It is called "Apex", and sometimes "Bead Filler" or "Stiffener". This member is essential for supporting a radial structure with a low degree of carcass rigidity since a ply cord has no angle, and is used for truck tires of bias type that carry heavy loads.

1.7 Rubber products manufacturing and energy consumption

Among rubber products manufacturing processes, the rubber materials milling process, the extruding process and the rolling process have a relatively high electric power consumption, which is more than 50 per cent of the total consumption, and the vulcanizing process has approximately 80 per cent of the total consumption.

It is most important to take countermeasures for energy conservation, but it should also be important to improve the yield in manufacturing processes. The yield rate is the ratio of the amount of a rubber product completed to the amount of rubber materials consumed when the rubber materials are processed.

The yield rate would be decreased due to a loss of weight during processing, an occurrence of defective units, etc. Since any occurrence of the defective units consumes their ration of materials, energy and labor expense, it results in directly increasing the cost. Therefore, attention should be paid to the following points for managements.

(1) Management of rubber materials: checking of the raw rubber, compounding ingredients etc., checking of characteristics of the milling rubber.

(2) Management of materials other than the rubber: as regards the tire, checking of the strength of tire cord, checking of the binding wire.

(3) Management of manufacturing conditions of equipments in each process: checking of operating conditions, checking of process specifications.

(4) Management of inspection: checking whether or not various conditions correspond to the drawings and standards for the manufacturing factory.

2. Tire Manufacturing and Energy Conservation

2.1 Concept of Energy Conservation

No factory consciously wastes fuel, electric power, etc. But how cleverly the factory consumes these energy sources is of prime importance.

The fact which we have become aware of through our inspection of the rubber factories carried out this time is that the amount of energy consumed was being recorded in almost all factories and controlled further by CPU in some factories. However, it is necessary to take the following two points into consideration: (1) the numerical values recorded in each factory are made the best use of them from the viewpoint of energy conservation, and (2) a receptible cooperation from the posts other than the post in charge is obtained in carrying out the energy conservation activities.

Viewed at this angle, we will refer to some basic conceptions at the time of promoting the energy conservation.

2.1.1 Understanding of current situation

First of all, the amounts of both materials and energy to be consumed, which are most important items in manufacturing products, should be soundly seized. In the case of the fuel, items to be controlled are as follows.

Amount of fuel consumption/Production amount (Weight of mixing rubber) → Fuel consumption per unit weight of mixing rubber

(Coal) Weight of coal consumption (t)/(t); per 1 ton of mixing rubber

(Heavy oil) Weight of heavy oil consumption (kl)/(t); per 1 ton of mixing rubber

(Gas) Amount of gas consumption (Nm^3)/(t); per 1 ton of mixing rubber

Since the calorific value of each fuel is already known, the unit of kcal/t can be also controlled.

In the case of the electric power, it should be as follows.

Electric power consumption/Weight of mixing rubber → Electric power consumption per the unit weight of mixing rubber

(kWh)/(t) ··· per 1 ton of mixing rubber

↓

860 (kcal/kWh) × Electric power consumption (kWh) kcal/t

Such a "unit requirement" or "energy consumption rate" is the basic numerical value in executing countermeasures for energy conservation. When carrying out the energy conservation activity until finishing it up to its index 100, there will go by some stages having a respective index value. Therefore, by confirming at each stage to what degree the index has been reduced, the effectiveness of the energy conservation could be ascertained. And as a result, the effectiveness in terms of money might be calculated.

The numerical values of the unit consumption should be hopefully confirmed once a month at least, also from the viewpoint of factory management.

Further, in order to seize the present situation, if the specifications of main equipment in factories and the wiring and piping installations are ready to be clearly shown, this makes it convenient to select the subjects of the energy conservation activity and to analyze the present situation.

Fig. 12 through Fig. 14 are examples showing the schematic diagrams of the piping or wiring systems for steam, electricity and cooling water.

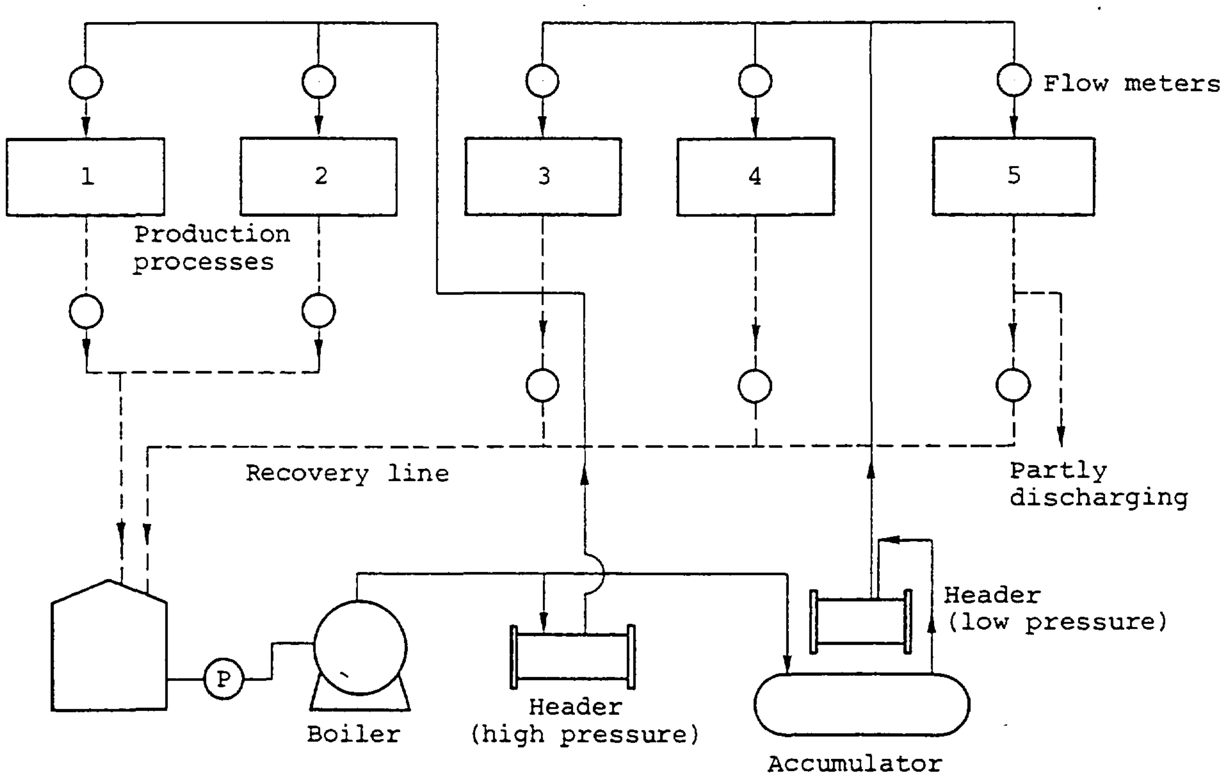


Fig. 12 Schematic diagram of the factory steam piping

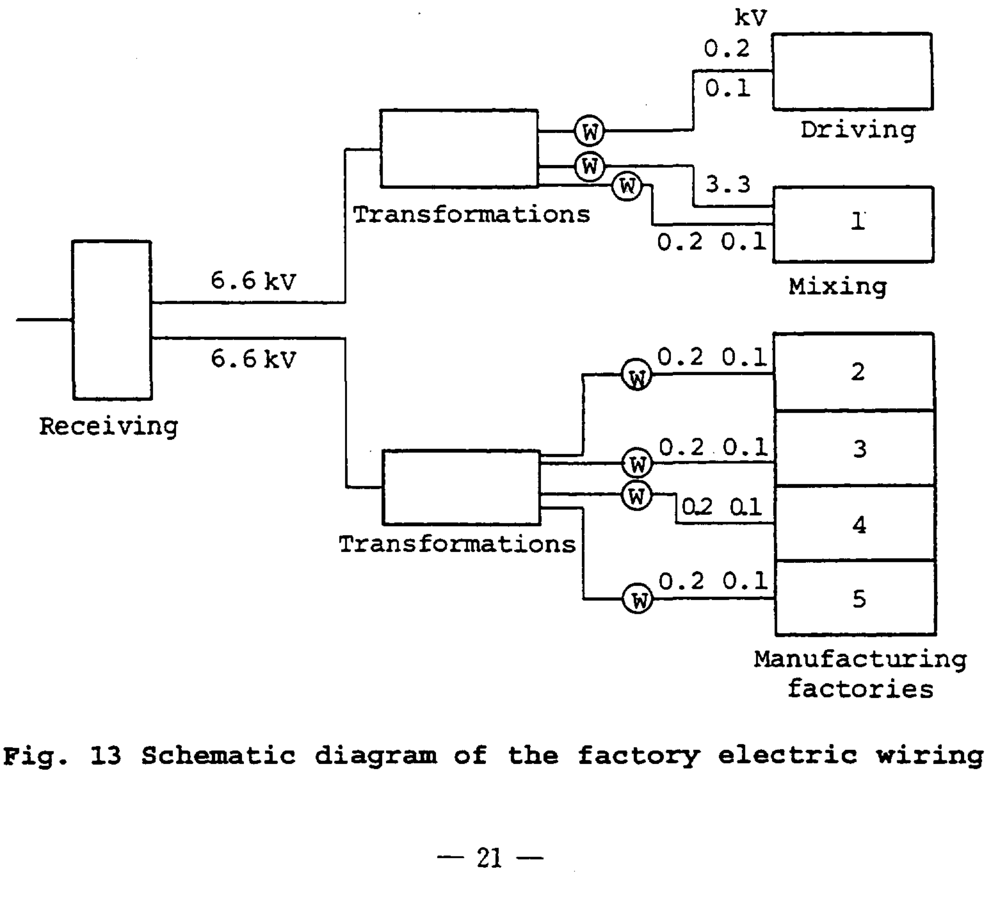


Fig. 13 Schematic diagram of the factory electric wiring

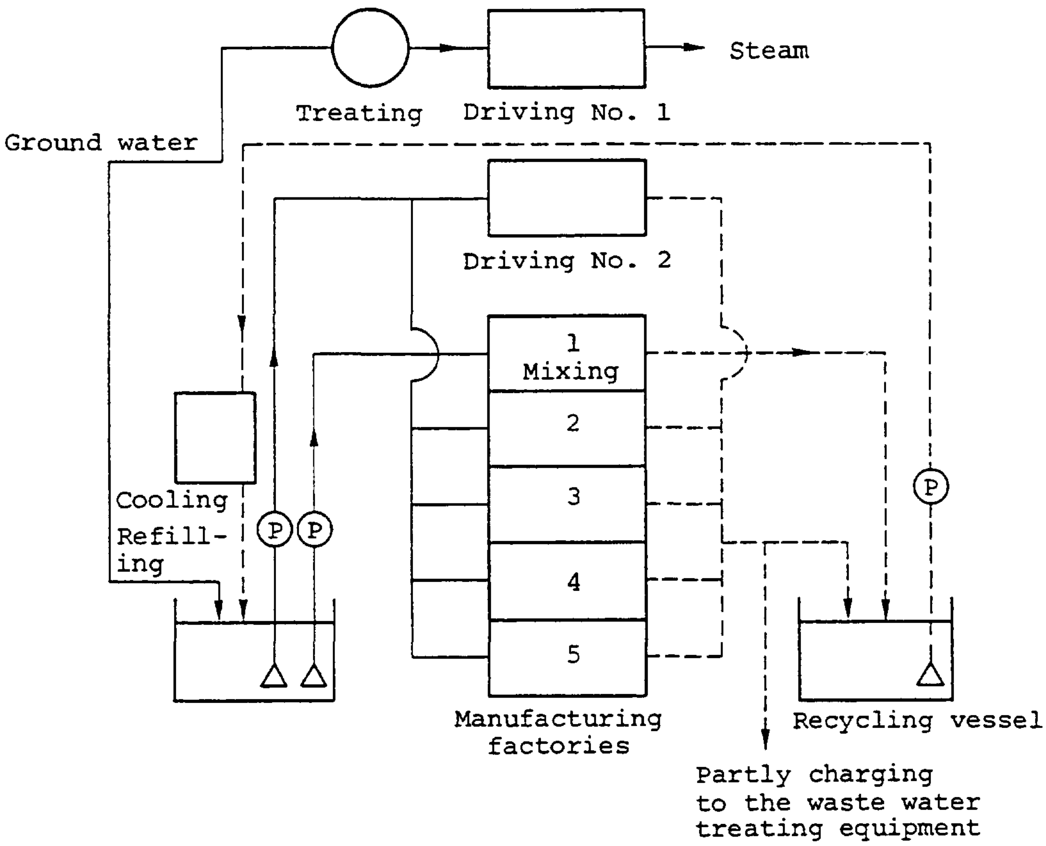


Fig. 14 Schematic diagram of the factory cooling water piping

2.1.2 Selection of themes

Carrying out the energy conservation activity means reducing the unit consumption. However, there are another measures to reduce the energy cost, that is, utilizing lower cost fuel and electric power, or making all employees present any proposals for a remedy of the energy conservation through increasing their awareness of it. Fig. 15 shows methods and countermeasures for reducing the energy cost. In the case of the rubber manufacturing factory, the electric power and the fuel are the main items to be controlled.

- Reduction in the energy cost
  - Reduction in the energy consumption rate (energy conservation)
    - Reduction in losses
      - Optimization of the equipment capacity Optimization of the manufacturing capacity of equipment
      - Prevention of the idle running and leaks
      - Reduction in failures of the equipment
      - Reduction in defectives
      - Recovery of the waste heat Utilizing the waste heat
    - Improvement in efficiency
      - Improvement and renewal of the equipment
      - Rationalization of operation processes
      - Establishment of advanced technologies Improving in the establishment of advanced technologies
  - Utilization of lower priced fuel and electric power
    - Cutting of the contract demand
    - Effective utilization of the time-of-day rate special contract
  - Improvement in employee's consciousness on the energy conservation
    - Leveling up of consciousness on the energy conservation
    - Activities for the energy conservation

Fig. 15 Methods and countermeasures for reducing in the energy cost

2.1.3 Organization for the energy conservation activity

In the case that the subject of worker's activity is either on the quality control or the cost down, almost all workers are consciously tackling with it, but in the case that it is on the "energy conservation", those members of a driving group (engineering group) tend to set to work unexpectedly. To be noted here, however, the people who are operating the manufacturing equipment are the workers in the manufacturing field. Once the course for energy conservation has been shaped and presented by the top classes, including the plant manager, the managers should explain this course to the workers in a way that facilitates their understanding of it, and present concrete measures or subjects to ask for the worker's cooperation in all its aspects. Since these workers are operating the same equipment and machines every day, they may well hit upon ideas for improving the pertinent subjects.

It is important that an organization which promotes the energy conservation activity should be established by the driving group, with strong cooperation of the manufacturing group and under the top class's understanding. This is needed because, when a new machine is required to be introduced with the purpose of improving the productivity or of carrying out the energy conservation activity, a considerable investment may be required. The management of the factories should execute the activity after checking and confirming the effectiveness of investment.

There seems to be a difference in estimating the rotation of investment between countries, but, in case of Japan, a recovery within three to five years is the target generally aimed at.

2.2 Energy Conservation in the Tire Manufacturing Factories

2.2.1 Energy consumption at tire manufacturing factories

Table 1 below shows an example of the state of energy usage in the tire manufacturing factories.

Table 1 State of the energy usage by processes

Process	Fuel (heavy oil)	Electric power	Air	Industrial water
Mixing	9.7%	32.8%	○	○ (Submergence, and cooling water)
Extruding	0.8	17.0	○	○ (Cooling water)
Sheeting	0.5	4.9		○ (Cooling water)
Cutting	0.2	5.7	○	
Beading	0.1	0.1		
Forming	0.1	4.7	○	
Vulcanization	81.1	4.3	○	○
Finishing and Testing	0.9	2.2		
Driving	1.9	17.0		○
Others	4.0	10.4		

2.2.2 Energy conservation at tire manufacturing factories

From the above Table, the process which consumes lots of fuel is the curing process, and both the refining section and the driving section consume the electric power prominently. The key points to improve the manufacturing processes from the viewpoint of carrying out the energy conservation are as follows.

Mixing: Heating up the crude rubber; Investigating on the peptizer; Investigating on milling conditions; Circulating the warm water; Exhausting fan.

Extruding: Temperature of the warming sheets; Investigating on the roll size (face length and number of roll); Heating the mouth rings; Controlling the remolding amount, Narrowing the width of cooling conveyer.

Sheeting: Same with extruding.

Vulcanization: Controlling the outgoing radiation; Improving the curing method; Preheating the die assembly; Shortening the time for exchanging the die assembly; Investigating the blowing air, Improving the ventilation fan.

Driving: Raising the temperature of boiler feeding water; Drain recovery; Jointing the steam and the warm water systems; Miniaturizing the boiler; Withdrawing the disused pipings; Reducing in the number of air compressor.

Others: Natural illumination; Controlling the steam and air leaks; Reducing the idling time; Inspecting the optimum capacities of equipment and motors; Installing the instruments and gauges.

In the case of the mixing process among the above said processes, the relationship between the internal mixer and the power load is shown in Fig. 16.

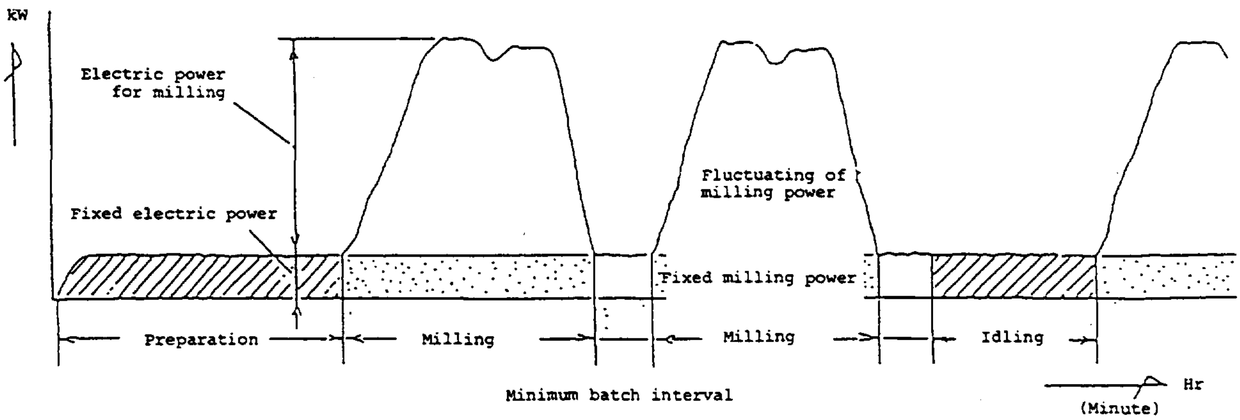


Fig. 16 Internal mixer and the power load

In order to reduce the electric power for milling process, the following items should be noted, as enumerated also in the key points for improving processes. Reducing the idling time should be important, too.

1) Heating up the green rubber (resulting in minimizing the peak electric power)
2) Investigating the peptizer (resulting in shortening the masticating time)
3) Investigating the milling conditions (resulting in shortening the cycling time etc.)

Further, almost all of the fuel or steam used is consumed in the curing process. Table 2 shows problems and measures for improving them.

Table 2 Problems and measures for improving them

Problems	Loss	Reasons	Measures for improving
Heavy loss of boiler heat	10%	High temperature of the exhaust gas	Recovery of exhaust heat
Heavy loss of outgoing heat in the vulcanization process	55%	Insufficient heat insulation	Complete thermal insulation
Heavy loss of the waste heat in the vulcanization process	20%	Much un-recuperated heat	Recovery of waste gas
Large amount of indistinct parts(unable to measure)	25%	Many leaks	Prevention of leaks
Small amount of recovered heat from the pre-process	18%	Much un-recuperated outgoing heat	—

From the table, it should be noted that special attention should be paid to thermal insulation or adiabatic measures, recovering the waste gas and preventing the leaks. In particular, main energy saving points are in the vulcanization process.

3. Examples of the Energy Conservation

There are many differences in the views of countries or companies (factories) to energy conservation including difference in the production amount and the types of equipment. Here, some leading tire manufacturers in Japan have been selected, and their activities to reduce the driving power of equipment and the effectiveness of the energy conservation activity are described.

3.1 Reduction of Electric Power for Driving Equipment

Outline of factory (one of the factories of A company)

Production item: Tires for automobile

Number of employees: 1,150

Energy consumption

Heavy oil (A, C): For boiler 8,316 kl/Y

Kerosene: For private power generation 8,858 kl/Y

Electric power: Purchased 74,906 MWh/Y

Private power generation 20,186 MWh/Y

Outline of the subject of the energy conservation activity

With regard to the electric power consumption of the driving equipment, which accounted for a big ratio among the equipment in factories, a 3 per cent reduction in the electric power unit consumption was set as the target, which was also the whole company's target, and thus the activity for the energy conservation was started. As a result, effectiveness was obtained mainly by both improving the nitrogen gas generating equipment and improving the equipment for factory cooling water.

Period for executing the activity and its members

November, 1992 through July, 1994, Driving group; 13 workers

Reasons for the selection of the subject

The electric power consumed by the driving equipment in the factories accounted for a comparatively high figure of 16.2 per cent of the total, and most of the power was the fixed one to be consumed regardless of an increase or decrease in production amount. In order to attain the target of 3 per cent reduction in the electric power unit consumption, the equipment was reviewed and a plan was established to improve them. Fig. 17 shows the ratios of the electric power consumption by processes recorded in fiscal year 1992.

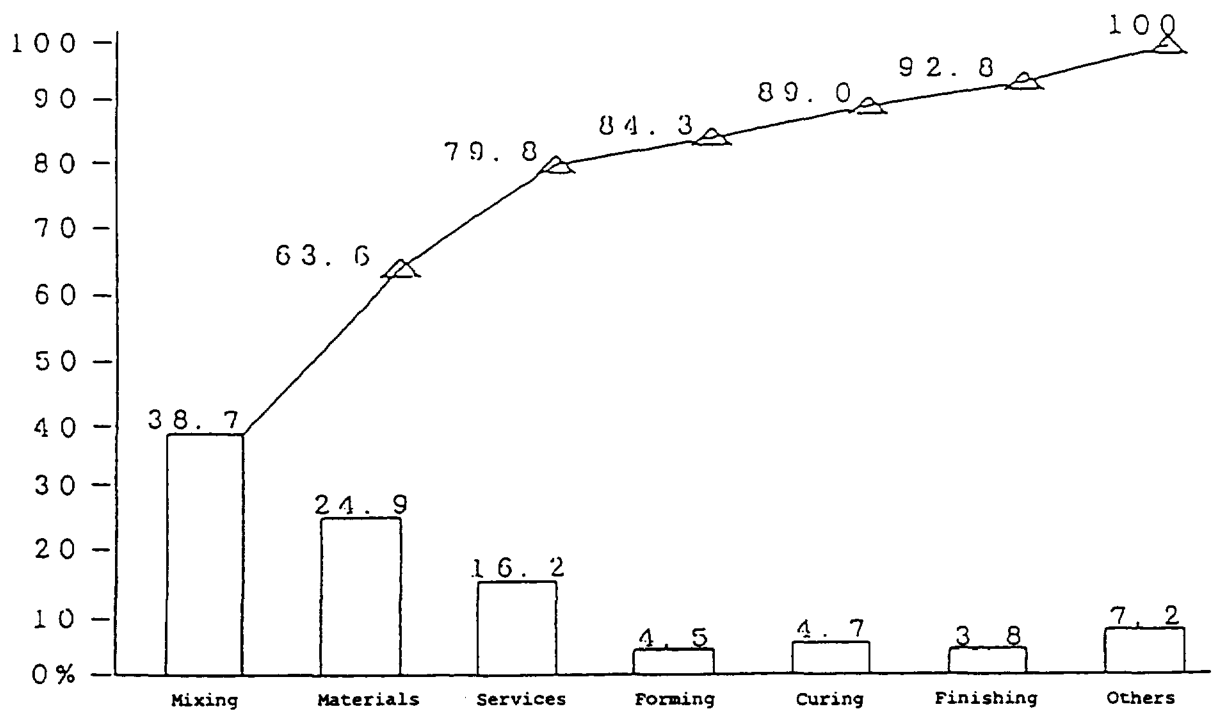


Fig. 17 Ratios of the electric power consumption by processes in fiscal 1992

Seizing of the present state and analysis of it

(1) **Seizing of the present state**

The driving equipment managed and controlled by members were those of a compressor, cooling water equipment, drainage system, treating equipment etc. The ratios of the electric power consumption of each equipment are shown in Fig. 18.

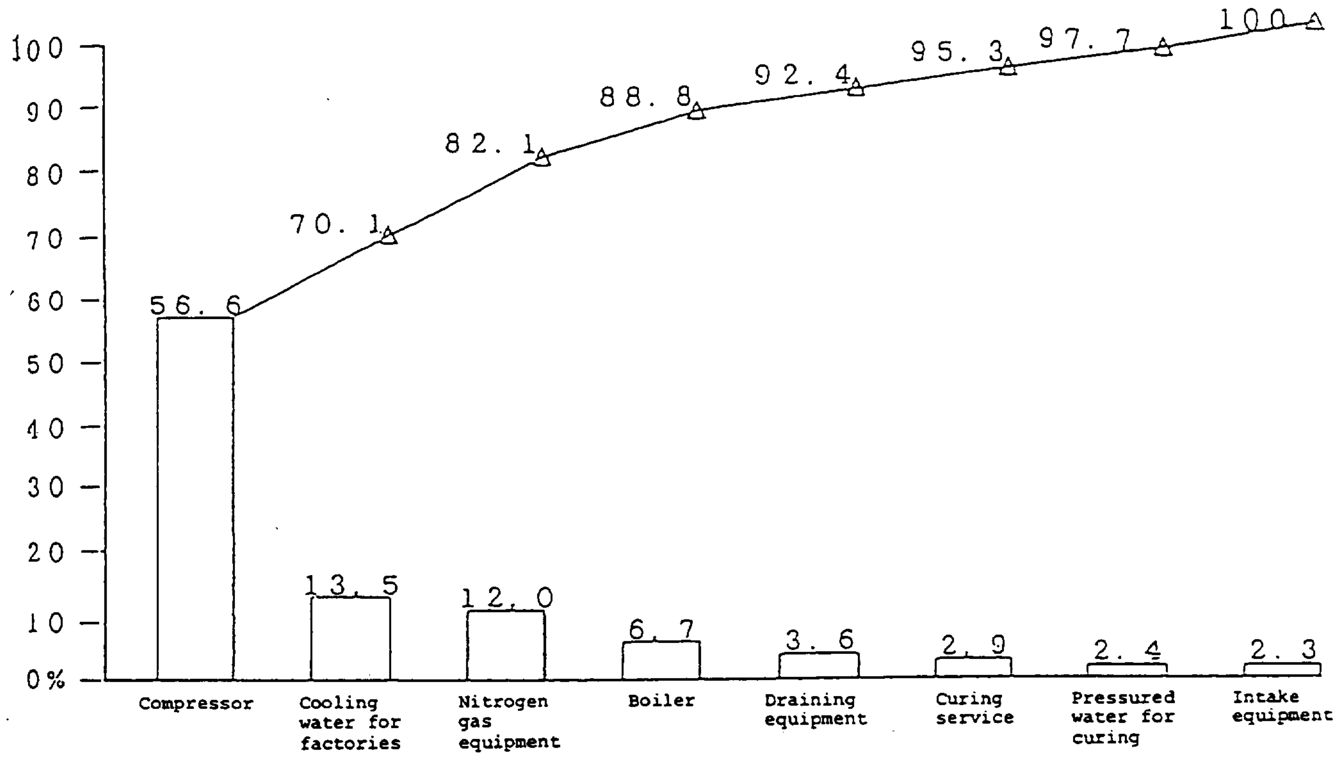


Fig. 18 Ratios of the electric power consumption of equipment

(2) **Analysis of the present state**

With regard to the compressors which consumed the highest amount of electric power, some countermeasures had already been taken, such as automating the operation by pressure switching, controlling the number of compressors, reducing the blasting pressure, reducing the air leaks etc. Therefore, the activity was directed to the equipment for cooling water to be supplied to factories, the nitrogen gas equipment, and the boiler equipment in which it seemed that any reduction in electric consumption could possibly be attained by fitting it to the amount of production.

Progress of the activity for the electric power conservation

(1) System of the activity

Since more than half of the members of the driving group were working in the three-shift duty, it arrangements were made that;

a) problems should be pointed out by all workers,

b) countermeasures for electric power conservation should be planned by the respective worker in charge,

c) executing the countermeasures and testing should be carried out by the regular daytime workers, and then, according to the results, the above a) through c) would be repeated.

(2) Establishment of the target

Since the target of the whole company was the "3 per cent reduction in the electric power unit consumption", the driving group accordingly established the same target as the 3 per cent reduction in the electric power unit consumption per production for the driving equipment.

(3) Problems

The production of factories had been decreased by 20 per cent or more compared to the past.

3.1.1 Improvement of nitrogen gas generators

(1) Role of nitrogen gas in the tire manufacturing process

a) Nitrogen gas was used in the tire curing process as a pressing source for pushing a crude tire to a die from the inside of the tire in the curing machine through a rubber bag.

b) The nitrogen gas absorbs air and separates it. The nitrogen gas was generated by the nitrogen generating equipment and pressured by the high pressure compressor to send it to the curing machine.

c) In order to prevent a deterioration of the rubber bag, the residual concentration of oxygen gas existing in the nitrogen gas should be made as low as possible.

The general role of the nitrogen gas generating equipment is shown in Fig. 19.

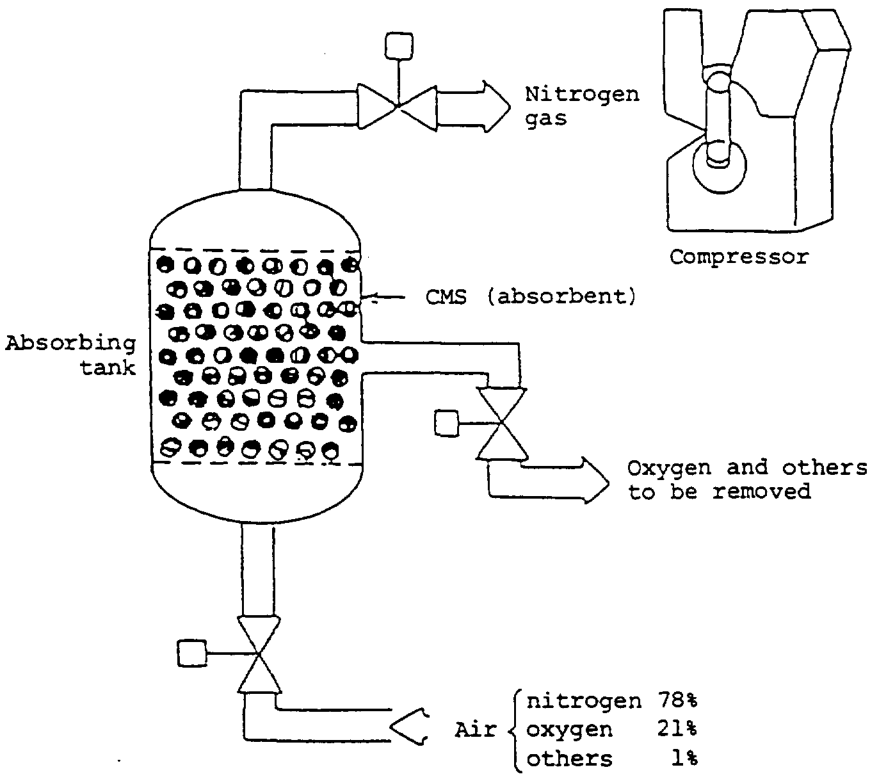


Fig. 19 Role of the nitrogen gas generating equipment

(2) Seizing of the present state

The nitrogen gas generating equipment consisted of three mechanisms, that is, one atmospheric regenerator and two vacuum regenerators, and the former consumed less electric power.

The average amount of nitrogen gas used is at present less than the corresponding capacity of one mechanism, but taking the fluctuation of flow amount into consideration, the said two vacuum regenerators were being operated continuously. Table 3 shows the nitrogen gas generating equipment by mechanisms.

Table 3 Mechanisms of the nitrogen gas generating equipment

Type of regenerator	Vacuum regenerator	Atmospheric regenerator
Regenerator	1, 2	3
Regenerating capacity	300Nm^3/h	300Nm^3/h
pressure	3.5kg/cm^2	5.5kg/cm^2
desorbing method after absorbing	Using a vacuum pump	Atmosphere relief with the raw air

A flowchart of the nitrogen gas equipment and the curing equipment is shown in Fig. 20.

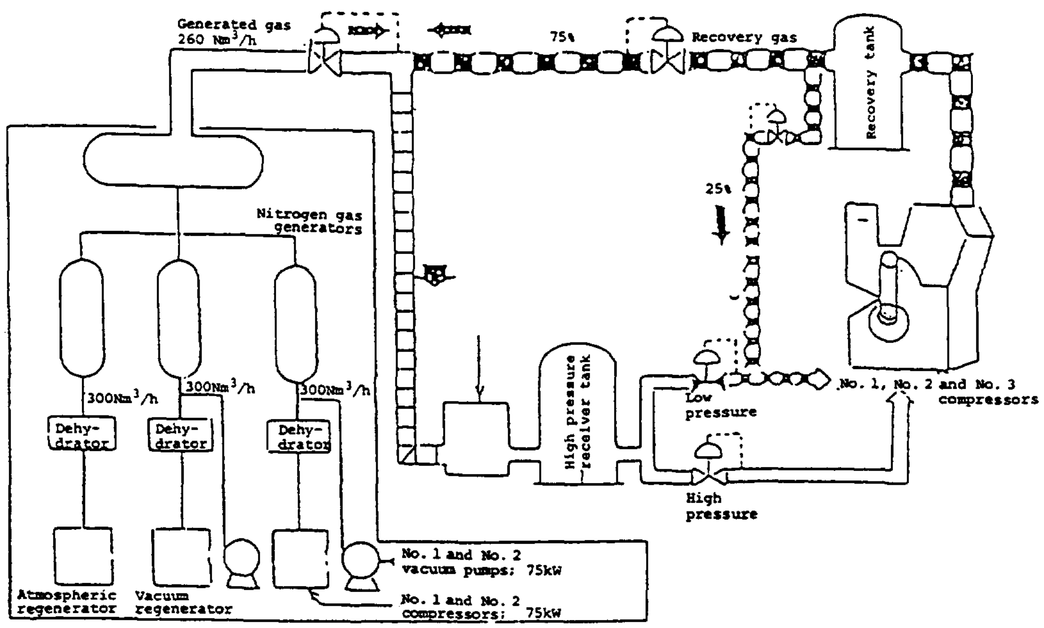


Fig. 20 Flowchart of the nitrogen gas equipment and the curing equipment

(3) Analysis of the present state

The reasons for operating two vacuum regenerators were because of coping with the fluctuations in the amount of gas to be treated and to stabilize the oxygen content in the nitrogen gas. If these were dealt with satisfactorily by operating only one regenerator, its effects would produce satisfactory results.

(4) Contents of countermeasures

a) The whole of the recovery gas was allowed to flow to the side of the high pressure compressor. (Improvement 1)

b) In the case of the above, since the oxygen pressure would rise when the standby high pressure compressor started its operation in response to a fluctuation of loading, one nitrogen generating equipment was started automatically to dissolve it.

c) The pressure controlling method for the nitrogen gas in the generating equipment was altered to a (flow + pressure) controlling method. (Improvement 2)

d) The high pressure compressor automatically started in response to pressure in the high pressure receiver tank, but the generating equipment was started automatically before it. (Improvement 3)

As a result, it was possible to cope with the fluctuation in the amount of gas and to stabilize the oxygen content, resulting in obtaining the effectiveness of the energy conservation, through adopting the practice that the one atmospheric regenerator was normally operating, and, when the loading was fluctuated, the one vacuum regenerator was operating in the on-off mode.

Fig. 21 shows a flowchart of integrated improvements, and Fig. 22 shows the effectiveness of the nitrogen generating equipment.

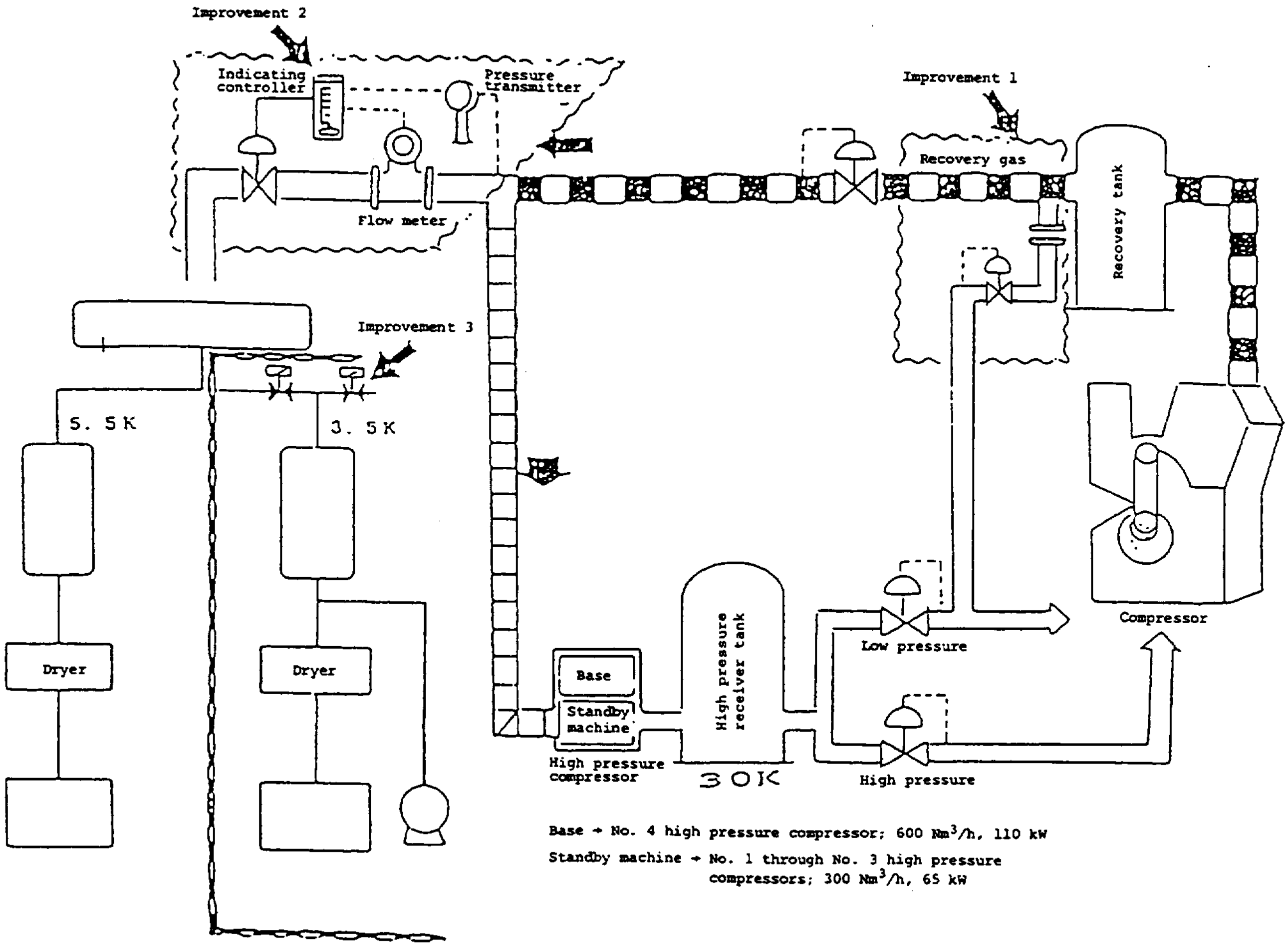


Fig. 21 Flowchart of integrated improvements

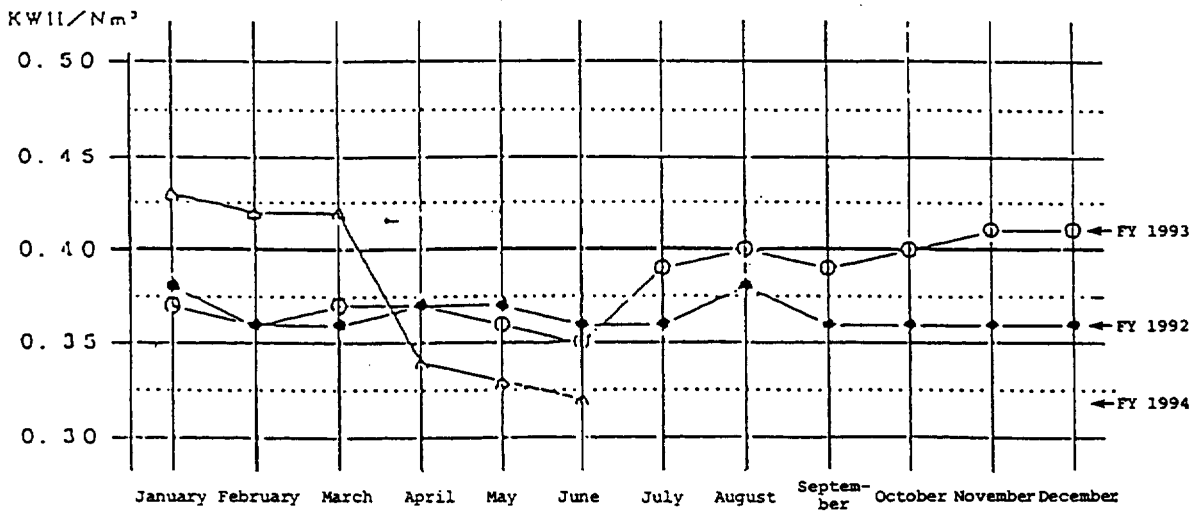


Fig. 22 Electric power unit consumption

3.1.2 Improvement of cooling water pumps at factories

(1) Seizing of the present state

The factory cooling water was used for cooling the rolling machines, various hydraulic units and compressors, for cooling the extruding process, etc.

The cooling water was supplied at 1.5 kg/cm^2 for directly cooling the rubber in a shower condition in which no pressure was needed, and 3 kg/cm^2 for the other usage.

A flowchart of the factory cooling water is shown in Fig. 23.

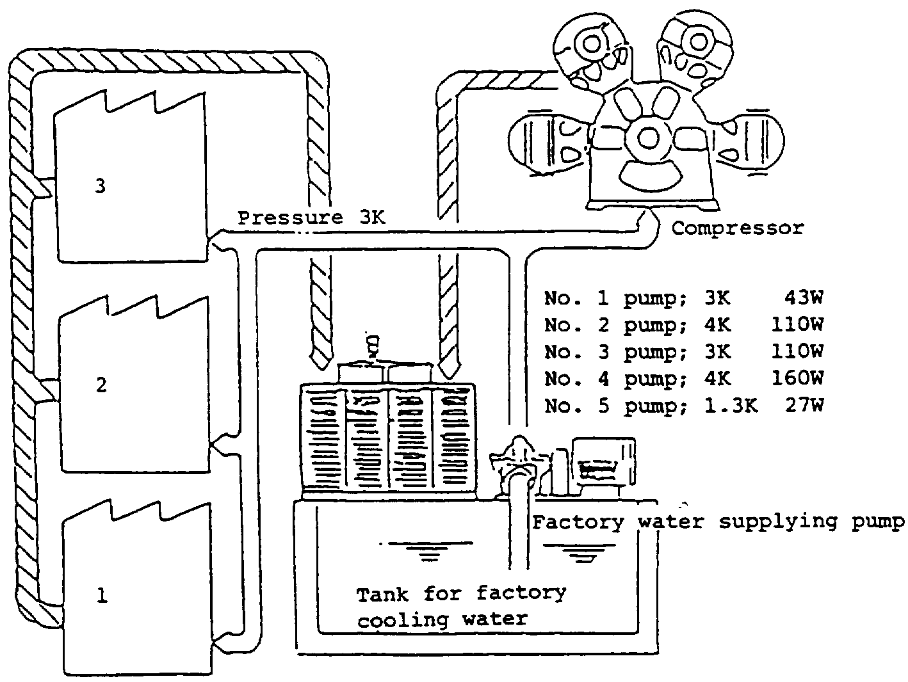


Fig. 23 Flowchart of the factory cooling water

(2) Analysis of the present state

a) Cooling of the milling machine and the hydraulic units could be carried out by the cooling water with a lower pressure.

b) The pressure of the compressor should not be lower than 3 kg/cm^2 from the viewpoint of protecting machines and their performance. However, if these points could be improved, the pressure in the 3 kg/cm^2-designed pipelines could be reduced, resulting in reducing the electric power to be consumed for pumps.

(3) Contents of countermeasures

Aiming at reducing the pressure of cooling water from 3 kg/cm^2 to 2 kg/cm^2, some countermeasures were carried out.

a) The cooling water system for compressors was separated from the factory side to be a dedicated system.

b) Since it was necessary that the cooling performance be degraded when lowering the pressure of the cooling water, the pressure was gradually lowered with the close cooperation of manufacturing workers and respective maintenance workers in charge, and problems were pointed out each time to establish countermeasures.

(4) Results

a) The prospect of 2 kg/cm^2, the target of the cooling water pressure for factories, had been acquired, and the pumps were so remodeled, resulting in reducing the electric power consumption.

Fig. 24 shows the course of tests for decreasing the supplying pressure of the factory cooling water, which were carried out in 1992.

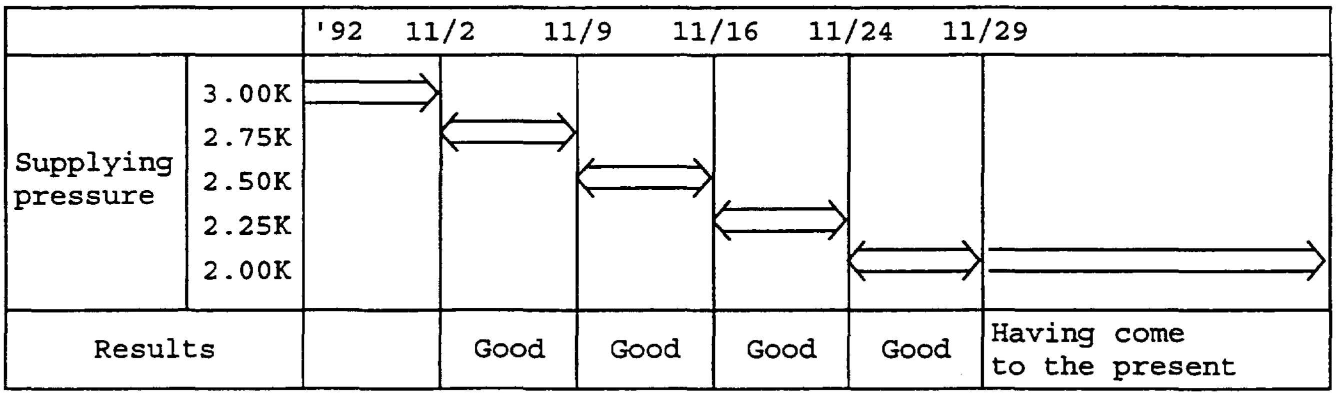


Fig. 24 Tests for decreasing the supplying pressure of the factory cooing water

b) By making the cooling water for compressors dedicated, the water treatment could have been easily carried out, resulting in improving the heat exchanging effectiveness. Fig. 25 shows the effectiveness of supplying the factory cooling water.

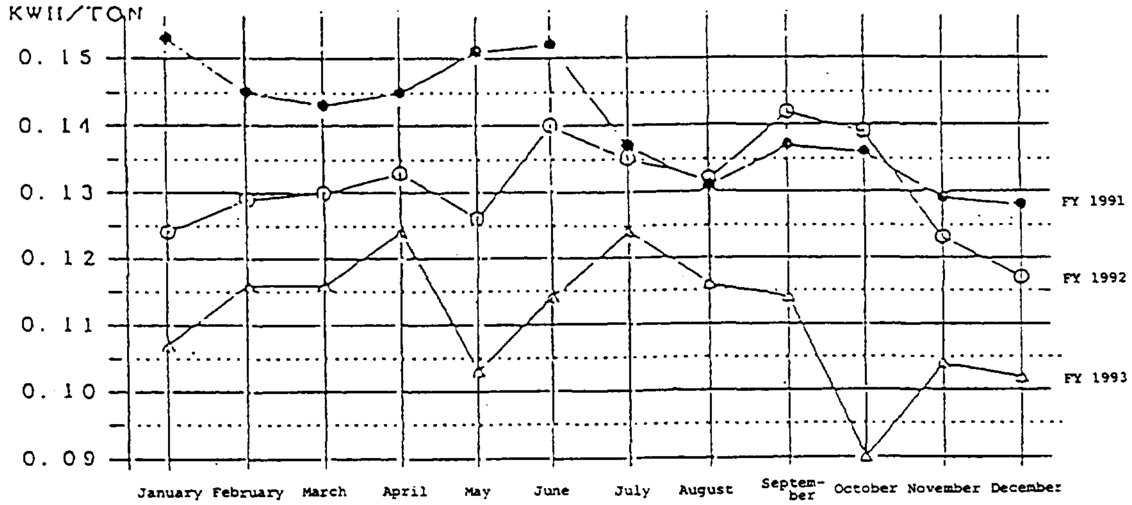


Fig. 25 The factory cooling water supplying effectiveness

3.1.3 Reduction of electric power for the boiler equipment

(1) Seizing of the present state

The boiler with a capacity of 50t/h was being operated, but the actual loading had been reduced by about 30 per cent owing to the countermeasures of the energy conservation for the secondary system.

(2) Analysis of the present state

The forced draft fan was operated through controlling the revolving speed, but the exhaust gas recirculating fan for a countermeasure against NO_x was still being operated by a tamper controller regardless of the lower loading which had been attained, and in addition there were many cases of a "closed" condition.

(3) Contents of countermeasures

Based on the control standard values of the Air Pollution Control Act and the present condition of loading, it was judged that there would be no problems even if the exhaust gas recirculating fan was closed, and accordingly the combustion air damper was regulated and the operation of the fan was stopped.

(4) Results

There was almost no change in the amount of NO_x, resulting in conserving the electric power for the exhaust gas recirculating fan. Fig. 26 shows a schematic diagram of the relation between the exhaust gas recirculating fan and the boiler.

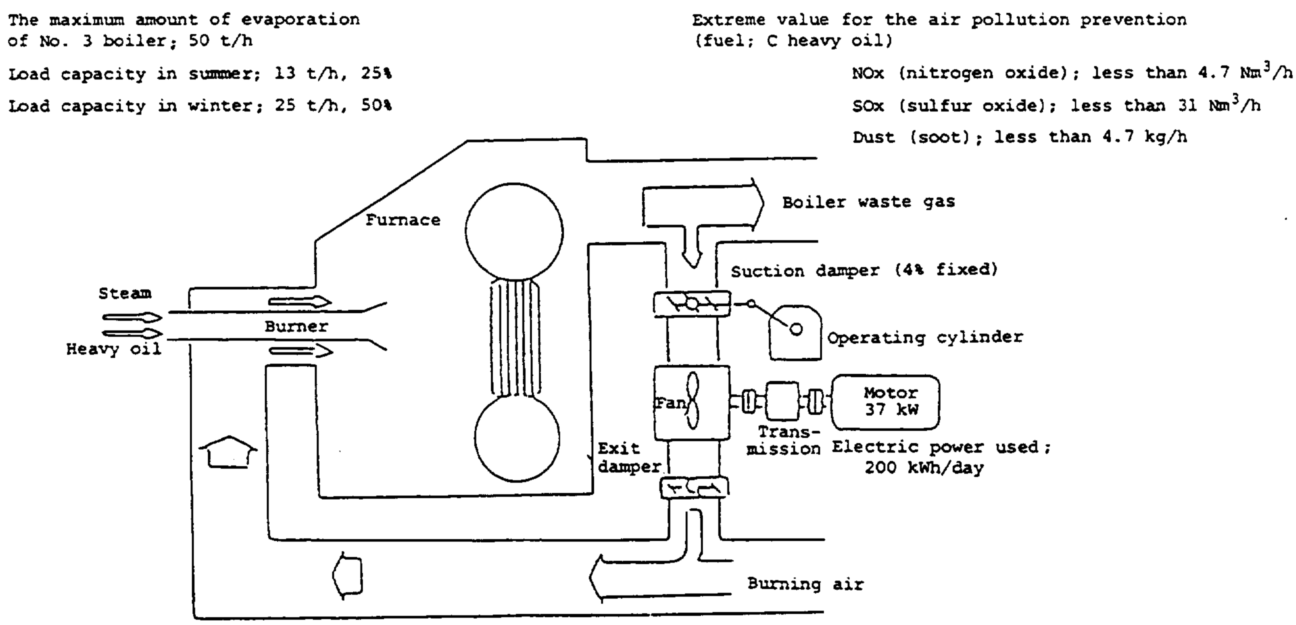


Fig. 26 Schematic diagram of the exhaust gas recirculating fan and the boiler

3.1.4 Effects after taking countermeasures

The above mentioned countermeasures taken for energy conservation in the three fields had the following effects shown in Table 4.

Table 4 Effects of countermeasures

Item	Effects (¥1,000/Year)
Improvement in the nitrogen gas generating equipment	6,900
Improvement in the factory cooling water pumps	2,200
Stoppage of the fans for the boiler exhaust gas	980

As the results that the countermeasures had been carried out with the target of 3 per cent reduction in the electric power unit consumption, a 3.8 per cent reduction had been attained regardless of the decrease in the factory production by 20 per cent or more, if the fixed electric power consumption was excepted.

3.2 Reduction in the Fuel Unit Consumption in Rubber Factories

Outline of the factory

Production item: Tires and tubes for bicycle, V-belts and so

Number of workers: 420

Amount of fuel consumption: Heavy oil; 2,854 kl/Y

Outline of the subject on the reduction in the fuel unit consumption

If the index of the fuel unit consumption in 1973 was made at 100, in 1976 it was decreased to 77.9 owing to the energy conservation activities, but in 1977 it was increased to 84.4. The activities for energy conservation in 1977 included repairing leaks, performing heat insulation on pipes etc without much investment. Since it was felt that such activities would not produce any excellent results, new activities for improving equipment and introducing new instruments were undertaken together with a measure of investments.

Term of the activities: 1978 through 1981

Members: Four workers of the driving brackish water group

3.2.1 Analysis of the present state

(1) Fig. 27 shows a transition of the index of the fuel unit consumption, in which it is noted that the fuel unit consumption in 1977 was raised.

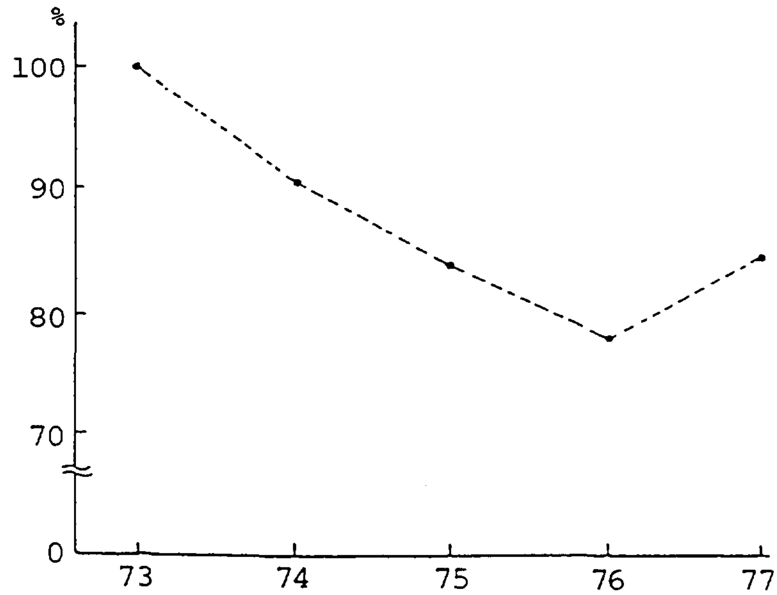


Fig. 27 Transition of the index of the fuel unit consumption

The fuel unit consumption had made good progress from 1973 through 1976, and improvements which had born full fruit were as follows.

1) A thorough heat insulation with 35 mm to 70 mm in thickness on the curing machine, the hot water piping installment, the hot water equipment, the steam piping installation, etc.
2) Recovery of the drain from both the curing machine and the hot water piping installation.
3) Adjustment and integration of both the steam piping and the hot water piping installations.
4) Raising the temperature of the boiler supplying water.
5) Improvement in the effectiveness of the hot water equipment by changing its type.
6) Rationalization of operating conditions for the hot water circulating installment.
7) Reduction in the cycle time through rationalizing the curing conditions.

(2) Cause and effect diagram

Fig. 28 shows the results of confirming where the energy losses existed.

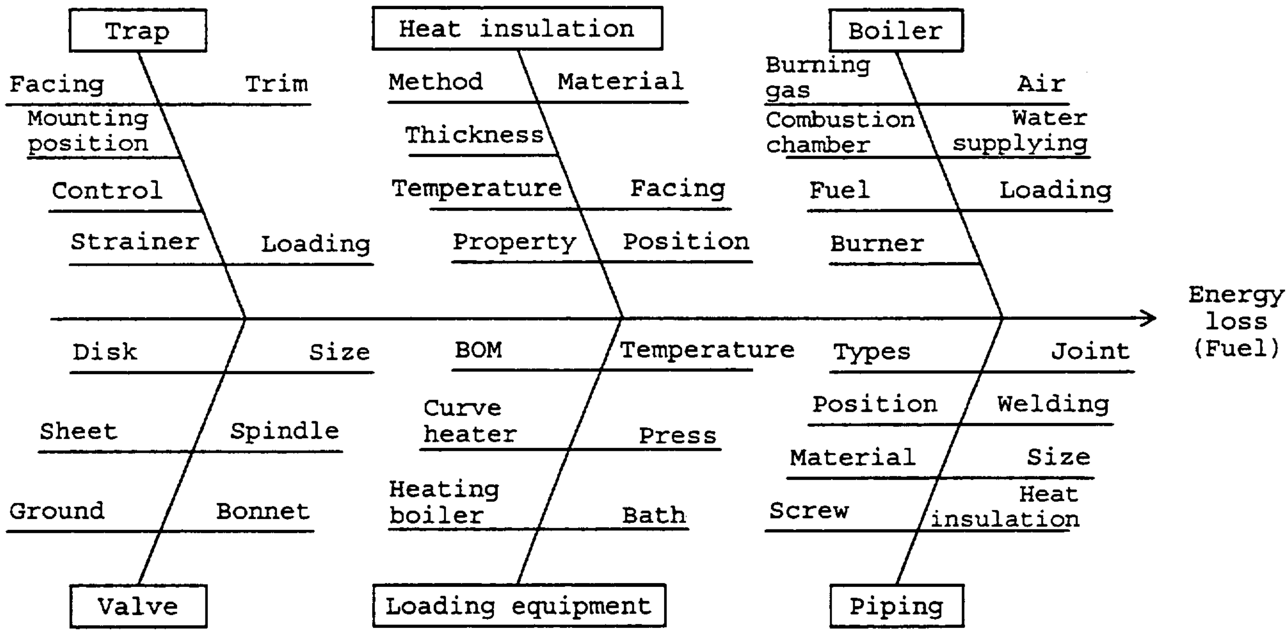


Fig. 28 Cause and effect diagram of the energy losses

a) Piping

There were many complex piping parts and naked pipes by installations.

b) Traps

There were some traps having an excessive discharging capacity against the loading, resulting in generating an energy loss. Further, such traps were located at a place where the inspection work was hard to carry out, and their actuation was sometimes difficult to judge.

c) Heat insulation

The main pipes were fairly heat-insulated, but some of the flange valves, pressure reducers and covers of the curing cans were not.

d) Loading equipment

1) The loading might be light in the case of operating the one machine, but its fluctuation became violent in the case of operating the

multi-equipment in parallel at the same time. Therefore, the boiler loading sometimes got 18t/h at the maximum against its capacity of 10t/h, resulting in decreasing the boiler pressure and in interfering with the production.

2) There were some curing equipment which threw away the steam each time when the curing processing was finished.

3) There were leaks of steam.

e) Valves

There were marked leaks from the ground parts of valves for a high pressure and from the parts of bonnets.

3.2.2 Contents of activities and scheduled term

Since the range of the activities for the energy conservation was wide, a long-team plan was established before carrying out the activities. Table 5 shows the contents of the activities and their scheduled term.

Table 5 Contents of the activities and their scheduled term.

Item	Contents	Fiscal year	
		78	79
Boiler	Heat recovery from the exhaust gas	○	
Boiler	Low oxygen combustion	○	
Piping system	Rationalization of the piping for the tire curing machine	○	
Trap	Improvement of the capacity of the tube heater trap	○	
Loading equipment	Recovery of the exhaust heat from the pot heater	○	
Trap	Improvement of the type of dryer trap		○
Loading equipment	Countermeasures for leaks from the piston valves		○
Loading equipment	Equalization of loads (installation of an accumulator)		○
Heat insulator	Thorough heat insulation		○
Valve	Countermeasures for outside leaks		○

(1) The target for the fiscal 1978

The 5 per cent reduction in the unit consumption index of the fiscal year 1977.

(2) Problems and countermeasures for these

a) Heat recovery from the boiler exhaust gas:

Temperature of the exhaust gas was 250℃ at the exit of the economizer, the gas thus being exhausted at a higher temperature. In order to lower this temperature, a preheater for the supplying water was installed at a place between the economizer and the chimney as shown in Fig. 29, to supply water to the feed tank and to recover the heat.

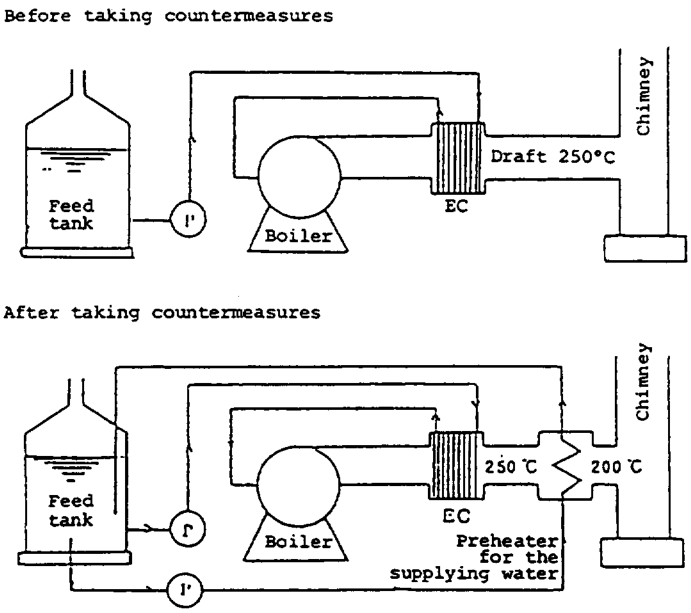


Fig. 29 Heat recovery from the boiler

b) The boiler had been operated with the oxygen content of about 3.7 per cent in the exhaust gas from the boiler. However, in order to reduce the holding heat of the exhaust gas, a low oxygen combusting equipment was installed to enable the boiler to operate at 2.5 per cent oxygen content in the exhaust gas.

c) Rationalization of piping installation for the tire curing machine: The piping installations for jacketing the tire curing machine were very complex and their total length amounted to 7m, most of which were composed of naked pipes. The complexity was because the piping had a structure in which two pipes enabled the tire to be cured at the same time, and therefore even if one of them got out of order, the other alone enabled it to be cured through closing the opposite valve. However, since there had not actually been such a one-pipe curing operation, the piping installation was altered as shown in Fig. 30, in which the piping was shortened to 4m and was thoroughly heat-insulated to reduce the heat loss due to outgoing radiation.

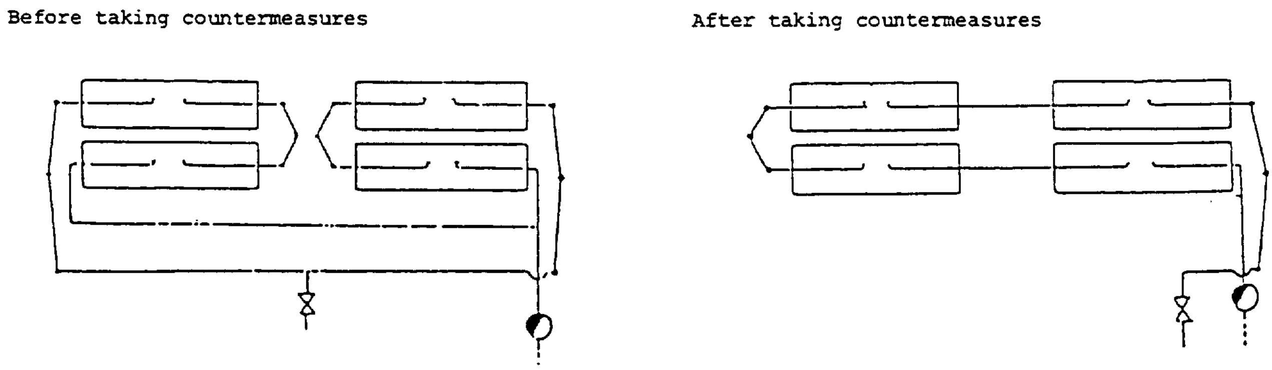


Fig. 30 Rationalization of piping installation for the tire curing machine

d) As a result of investigating the discharging capacity of the tube heater traps, it was found that some traps had an excessive discharging capacity against the loading. Hereupon, the traps made by three manufacturers were compared and tested, the results of which are shown in Table 6.

Table 6 Results of comparing and testing on the traps manufactured by three makers

Maker	Amount of discharging	Temperature of die	Unit price
M maker	5.7kg/h	175℃	¥8,000
Y maker	9.5kg/h	175℃	¥8,000
T maker	11.2kg/h	175℃	¥8,000

From the above results, traps manufactured by M maker, which showed the smallest amount of discharging, were adopted to replace the existing 100 traps.

e) Recovery of the exhaust heat from the pot heater:

The steam was thrown away from the pot heater each time the curing processing was finished. This steam became a source of heat for the bath through installing a heat exchanger in the way of the exhausting piping as shown in Fig. 31.

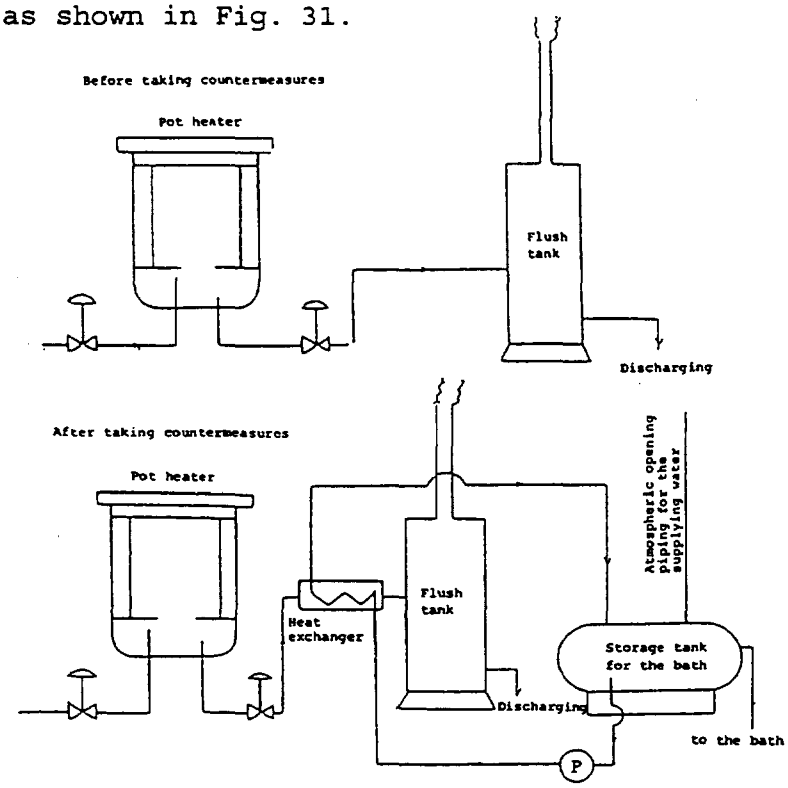


Fig. 31 Recovery of the exhaust heat from the pot heater

(3) The target for the fiscal 1979

The 5 per cent reduction of the actual results of the fiscal year 1978

(4) Problems and countermeasures for them

a) Reviewing and changing the type of dryer traps:

Since the traditional traps were located at a place where the inspection work was difficult to carry out and they were of a continuously discharging type, it had been difficult to judge their actuation. Therefore these traps were replaced by those of an intermittent type.

b) Countermeasures for leaks from piston valves of the tire curing machine:

With regard to the amount of steam used for the curing machine, the difference in its amount was great, between its actual usage indicated by the flow meter and the discharged amount of drain measured by the tire curing model machine. The measuring method is shown in Fig. 32.

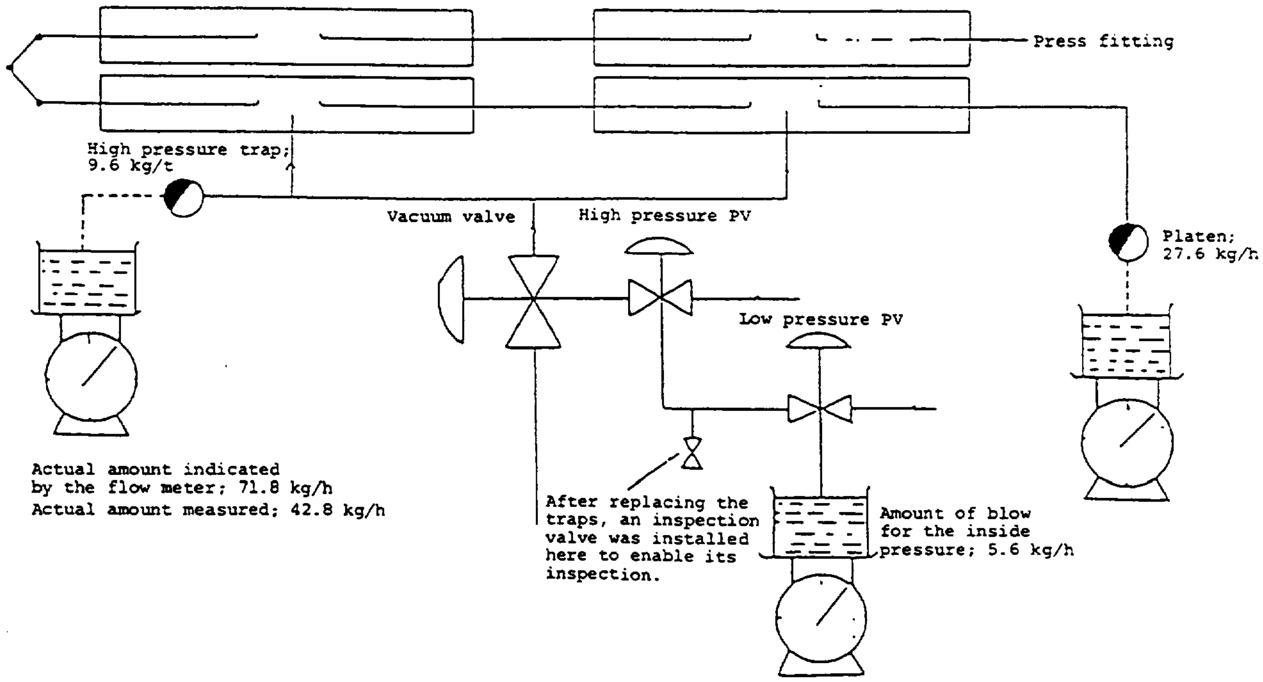


Fig. 32 Drain measuring method by the tire curing model machine

Results of the actually measured amount of steam and the indicated value by the flow meter were 42.8 kg/h and 71.8 kg/h respectively, resulting in a loss of 29 kg/h. As a result of an investigation, it had been found that there was a leak in the high pressure piston valve. Thereupon, the valve was replaced. After that, the flow meter indicated 52.6 kg/h.

c) Equalization of loads (installing of an accumulator):

The said multi-and-parallel equipment operation got a heavy loading, even if each loading of them was light, resulting in a drop in the boiler pressure. Therefore, the reserved boiler had been usually operated for 15 minutes at the time of preheating in the morning, and thus a two-boiler operation had been carried out. In order to solve this problem, an accumulator was installed. As a result, the loading did not exceed 10t/h, there were no pressure drops and the two-boiler operation was disused.

d) Thorough heat insulation:

Since the heat insulation had not been fully applied to those in factories such as the valves, flanges, pressure reducers and curing can covers, it had been executed on all of those. Further, it had also been executed on the traps which were already changed in the preceding fiscal year.

e) Countermeasures for leaks to the outside of valves

Since there had been marked leaks from the ground parts of valves for a high pressure and the parts of bonnets, some components were replaced and, in case any repair on the old ones was difficult, they were renewed. By taking the countermeasures, all problems of fifty leaks in number have been solved.

3.2.3 Effects after taking countermeasures

The countermeasures for improving the fuel unit consumption in the rubber factories had been carried out for two years, and satisfactory effects raising the original target were produced, the results of which are shown in the following Table 7, and the transition of the index of the fuel unit consumption shown in Fig. 33.

A comparison of the investments with the effectiveness in terms of money is shown in Table 7. The table shows that the energy conservation activities carried out that time had obtained satisfactory results even from the viewpoint of the return on investment.

Table 7 Summary of effects (Unit: ¥1,000/Year)

(Unit: ¥1,000/Year)

Item	Contents	Expected effects	Fiscal 1978	Fiscal 1979
Boiler	Heat recovery from the exhaust gas	224	1,286	
Boiler	Low oxygen combustion	619	1,857	
Piping system	Rationalization of piping for the tire curing machine	263	394	
Trap	Improvement in the capacity of the tube heater traps	4,866	4,521	
Loading equipment	Recovery of exhaust heat from the pot heater	216	1,295	
Trap	Improvement in the type of the dryer traps	116		154
Loading equipment	Countermeasures for leaks at the piston valves	3,799		8,989
Loading equipment	Equalization of loads (installation of the accumulator)	412		2,708
Heat insulation	Thorough heat insulation	1,269		1,666
Valve	Countermeasures for the outside leaks from the valves	1,282		2,219
Effectiveness in terms of money		13,066	9,353	15,645
Investment		—	2,540	20,050

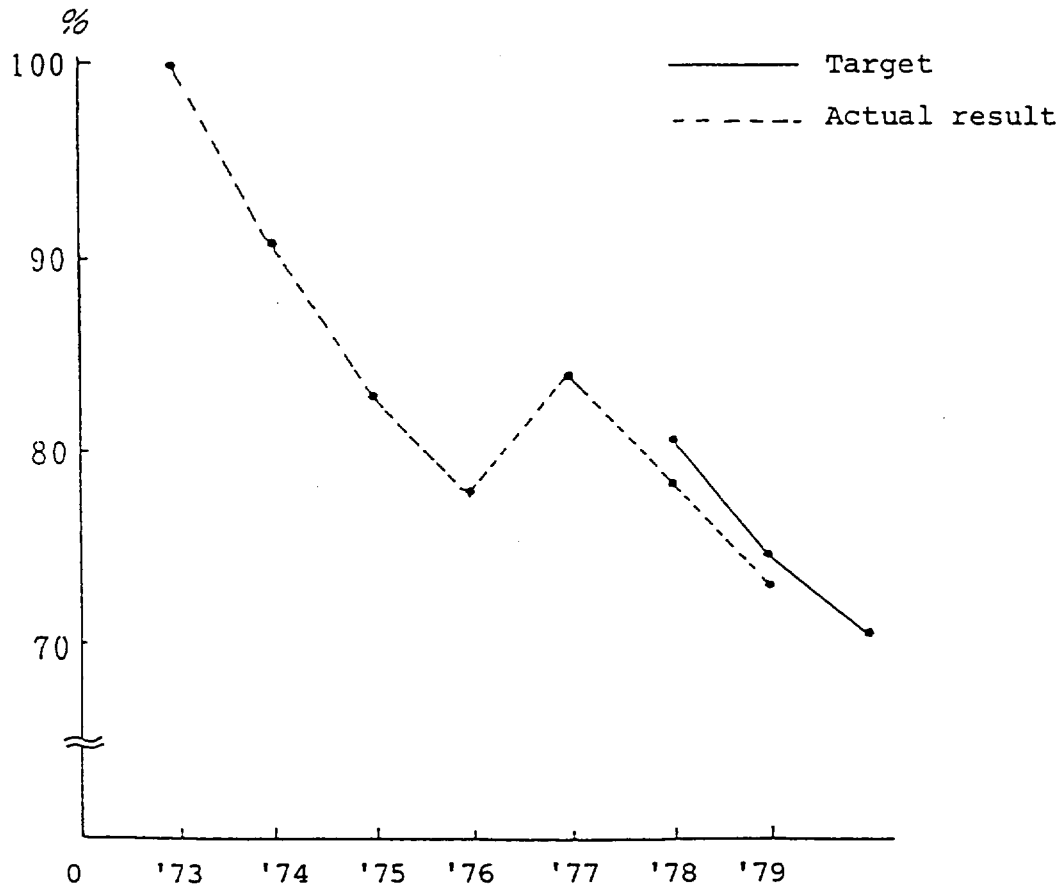


Fig. 33 Transition of the index of the fuel unit consumption

4. Conclusion

The rubber industry, including the tire manufacturing, has a history of more than a 110 years, and it has especially grown remarkably in the latter half. At the same time, energy consumption has increased rapidly with its growth. Under these circumstances, the activities on energy conservation have been carried out positively in every factory.

In carrying out energy conservation, the main points which have already been described are listed once again as follows:

(1) The energy consumption rate at present should be seized and recorded by all means.

(2) The specifications of the main equipment and the wiring and piping installations in factories should be shown clearly.

(3) As shown in Fig. 15, the methods and countermeasures for reducing the energy costs should be fully investigated, and then they should be initiated.

(4) The cooperation of workers affords great support.

(5) The top classes should exhibit understanding of the workers in charge of the energy conservation activities, and, at the same time, should ascertain the effectiveness of the investment in the case of costing a great deal.

At present, one of the international problems to be solved in parallel with energy conservation is the establishment of countermeasures for environmental problems. Since global warming is advancing, various subjects, such as reducing carbon dioxide etc., are being discussed. We believe that the clean earth can be regenerated only when we use valuable energy effectively. Therefore, countermeasures for energy conservation and for global warming should not be considered and discussed separately.

HANDY MANUAL

PLASTIC FORMING INDUSTRY

Output of a seminar on Energy Conservation in Iron Casting Industry

Sponsored by

United Nations Industrial Development Organization (UNIDO)

and

Ministry of International Trade and Industry (MITI), Japan

Hosted by

State Economic and Trade Commission
People's Republic of China

Ministry of Industry
Socialist Republic of Viet Nam

Organized by

The Energy Conservation Center (ECC), Japan

1998

PREFACE

The conservation of energy is an essential step we can all take towards overcoming the mounting problems of the worldwide energy crisis and environmental degradation. Although developing countries and countries with economies in transition are very much interested in addressing the issues related to the inefficient power generation and energy usage in their countries, only a minimum amount of information on the rational use of energy is available to them. Therefore, distributing the available information on modern energy saving techniques and technologies to government and industrial managers, and to engineers and operators at the plant level in these countries is essential.

In December 1983, UNIDO organized a regional meeting on energy consumption and an expert group meeting on energy conservation in small- and medium-scale industries for Asian countries. The outcome of these promotional activities prompted UNIDO to initiate a new regional programme designed to increase the awareness and knowledge of government officials and industrial users on appropriate energy saving processes and technologies. In 1991, the first project, Programme for Rational use of Energy Saving Technologies in Iron and Steel and Textile Industries in Indonesia and Malaysia (US/RAS/90/075), was approved and financed by the Government of Japan.

The successful completion of this project prompted UNIDO to request the financial support of the Government of Japan to carry out similar projects under this programme in other Asian countries. Since 1992, under continuous support of the Government of Japan, three other projects have successfully been completed: Rational Use of Energy Saving Technologies in Pulp and Paper and Glass Industries in the Philippines and Thailand (US/RAS/92/035); Ceramic and Cement Industries in Bangladesh and Sri Lanka (US/RAS/93/039); and Plastic Forming and Food Industries in India and Pakistan(US/RAS/94/044).

This year UNIDO is carrying out the programme in China and Vietnam, targeting two energy intensive industrial sub-sectors: iron casting and rubber industries.

Iron casting industry consumes a substantial amount of energy. Excessive use of energy is usually associated with many industrial plants worldwide, and iron casting plants are no exception. Enormous potential exists for cost-effective improvements in the existing energy-using equipment. Also, application of good housekeeping measures could result in appreciable savings in energy. Therefore, it is imperative to introduce and distribute information on modern energy-saving techniques and technologies among the parties concerned in government and especially, at plant level, in industries.

To achieve the objectives of this programme, UNIDO has adopted the following strategy:

1. Conduct plant surveys to characterize energy use and to identify measures to improve energy conservation at the plants.

2. Prepare handy manuals on energy management and on applicable energy conservation techniques and technologies.

3. Organize seminars to discuss the content of the handy manuals and the findings of the plant surveys with government officials, representatives of industries, plant managers and engineers.

4. Distribute the handy manuals to other developing countries and countries with economies in transition for their proper use by the targeted industrial sectors.

UNIDO prepared this handy manual for the iron casting industry, with the cooperation of experts from the Energy Conservation Center, Japan(ECCJ), on energy saving technologies in the framework of this UNIDO programme. It is designed to provide an overview of the main processes involved in iron casting, and to present a concise outline of the applicable energy saving measures.

Appreciation is expressed to the following institutions for their valuable contribution to the successful preparation and publication of this manual:

The State Economic and Trade Commission of the People's Republic of China;
The Ministry of Industry of the Socialist Republic of Viet Nam;
The Ministry of International Trade and Industry of Japan; and
The Energy Conservation Center, Japan.

Contents

Energy Conservation in Cast Iron Foundry

1. Manufacturing of castings and energy

The foundry sector is well recognized as one of the supporting industries for the machinery and assembling industry. With a recent remarkable economic development in Asia, the production of castings, as a part of process materials in every engineering industry, has been increased; that of the Asian region is the highest in the world. However, the production of castings per capita is only 8.2 kg, which is lower than the world average of 13.6 kg. This fact shows that the production of castings will certainly increase, along with economic growth, not only in the Asian region, but also in developing countries.

From another point of view on economic development, the increase in the amount of energy consumption has become a great problem for mankind. Energy problems, such as limited fossil fuels, global warming caused by carbon dioxide generated by combustion, air pollution caused by other oxides, destruction of plants and world heritage buildings caused by acid rain generated by sulphur oxides, radioactive wastes from nuclear power plants, etc. to be continued into the 21st century, are important problems which are inevitable for the survival of mankind.

Since a large amount of energy is consumed in melting metals at high temperatures, the foundry sector has to be a source of various kinds of pollution; on the other hand, it plays a role in recycling a large amount of metal scraps occurring in a modern society. Thus, the production of castings has a lot of global environmental problems to be solved in the future. The development of an earth-friendly casting production process is the highest priority on the list in the foundry industry.

2. Production of cast iron and energy consumption

2.1 Cast iron

The term "cast iron" is a general term for "gray iron castings" and "spheroidal graphite cast iron castings". Since cast iron is easy to manufacture and its manufacturing cost is low, and, in addition, it has various physical and chemical properties, it is used to the greatest extent among metal products in almost all areas of industries, including the automobile industry. The annual production of cast iron castings in the world is over 50 million tons.

Gray iron castings are distinguished by good castability, abrasion resistance, damping capacity, corrosion resistance, machinability, etc.; they have been used for a long time and are produced in the largest amount among the various forms of castings. It forms about 75 per cent of the total production of cast iron.

Spheroidal graphite cast iron is superior to gray cast iron in mechanical properties, especially in ductility. Though only a half century has passed since the invention of spheroidal graphite cast iron, its production has been increasing year by year since its utilization technology was established; it reaches 13 million tons, which is 25 per cent of all cast iron and a further increase is also expected in the future. The 21st century may be called the age of spheroidal graphite cast iron.

Though malleable iron castings are a parity of cast iron, statistically they are usually excluded from cast iron. Since malleable cast iron has to be heat-treated in the process of its manufacturing for long hours at high temperature in order to improve its mechanical properties, a large amount of energy has to be consumed; the rate of energy consumption per ton of malleable cast iron is four or more times that of cast iron. Therefore malleable cast iron is replaced with spheroidal graphite cast iron and its production has remarkably decreased.

2.2 The production of cast iron and energy consumption rate

The process of manufacturing iron castings is mainly divided into the melting process where metal is melted at high temperature over 1400°C and the molding process where a mold is prepared into which molten iron is poured. It is obvious that of these two processes the melting process consumes most of the cast iron manufacturing energy. Though iron castings are mainly used as cast for final products having necessary properties, some of them may be subjected to heat treatment to acquire necessary properties. The amount of energy consumed varies depending on the materials, and it is said that 50 to 90 per cent of whole energy for the production of iron castings is consumed in the melting process.

To ensure energy conservation in cast iron foundry, it is necessary to grasp the amount of energy consumed in them and to record the kinds and amounts of energy used in the foundry every month and every year. Since the amount of energy used is expressed using a different energy consumption rate for each kind of energy, the total consumption of heat is obtained by summing up every kind of energy consumed (kcal) after calculating the amount of energy consumed using the respective heat consumption rate.

Naturally, this total amount of heat varies depending on the change in the production volume, and it is impossible to evaluate the state of energy conservation only by the total amount of heat. The value obtained by dividing this total amount of heat by the weight of production (in tons) is called the unit requirement for converting the amount of heat of energy (kcal/ton) and is used as an evaluation standard.

2.3 The yield of products and the energy consumption rate

The energy consumption rate is a value obtained by dividing the total consumption of energy by the production volume by ton, and the yield of products, that is, the ratio of the weight of final products to that of raw materials used has a great influence on the energy consumption rate. It is indispensable for reducing the unit requirement to improve the yield of products, which results from the foundry technology accumulated in each process of manufacturing of castings.

(a) The yield of melting

The yield of melting is defined as the percentage of the weight of molten metal cast in the mold against that of raw materials charged in the melting furnace. The yield of melting becomes worse because of metal loss due to oxidation in the melting process, metal adhesion to the furnace wall, ladle, etc., molten metal disposal due to improper chemical compositions and temperature, failure by poor pouring into the mold, residual molten metal due to rough estimation of weight, etc.

(b) The yield of casting

The cast shape against its final shape is planned prior to pattern making; some surpluses are needed for sound castings, such as machining allowances, pattern draft, padding for better directional solidification, wall thickness allowances covering dimensional fluctuation, etc. Based on the above shape, risers and gating system are designed, that is, proper risers to conpensate the shrinkage of molten metal through solidification, and gating system to prevent any damage on castings by controlling speed of molten flow and to avoid any slag inclusions into castings.

The yield of casting is defined as the percentage of the weight of deliver castings against cast weight including whole surpluses of the avobe.

The yield of casting is reduced by the deformation of the mold during molding caused by pattern, such as loosening, low accuracy, insufficient strength, obsolescence, insufficient draft angle, etc., by unnecessary large risers and gating system, by expansion of the mold due to weakness of molding sand, by lifting of the cope and leaking of molten metal due to clamping of the mold and an insufficient weight, etc. Adversely, the yield can be improved by using a cylindrical sleeve ensuring heat insulation of the riser, a heat generating sleeve actively heating the riser by exothermic reaction, or a chiller for thick parts to reduce the size of the feeding head, etc.

(c) The percent defective of castings

Some castings are judged to be rejected according to the inspecting standard in the finishing and inspection process before shipment. Defective castings show their defects in various forms, and causes of defects are not simply connected to defective phenomena. Practical information on all the processes of manufacturing of castings and a lot of experience ensuring correct evaluation are necessary for taking measures against defects. Taking measures against defects in casting correctly found may sometimes lead to lowering of the yield, but it is sure to be increased on the whole by the reduction in the percent defective. Also in melting, the quality of cast iron obtained can vary subtly depending on the raw materials and melting conditions. Shrinkage cavities and chills can be caused frequently in castings even with the same chemical compositions as molten metal. This is explained by oxidation and melting of the cupola. It is the accepted view that high temperature melting over 1550°C is necessary to prevent the above phenomenon. Raising tapping temperature will lead to consumption of excessive energy, but energy conservation can be realized by lowering the percent defective of castings.

2.4 Cast iron melting and energy conservation

2.4.1 Cast iron melting furnace

Fig.1 shows the kinds of cast iron melting furnace. Today the percentage of cupolas and induction furnaces used for cast iron melting is obscure due to lack of proper statistics. Systems with a cupola used for primary melting formed about 85 per cent in the 1970s, but it was remarkably reduced to 63 per cent around 1980; and after that cupolas may be used at a percentage of 50 to 60 per cent.

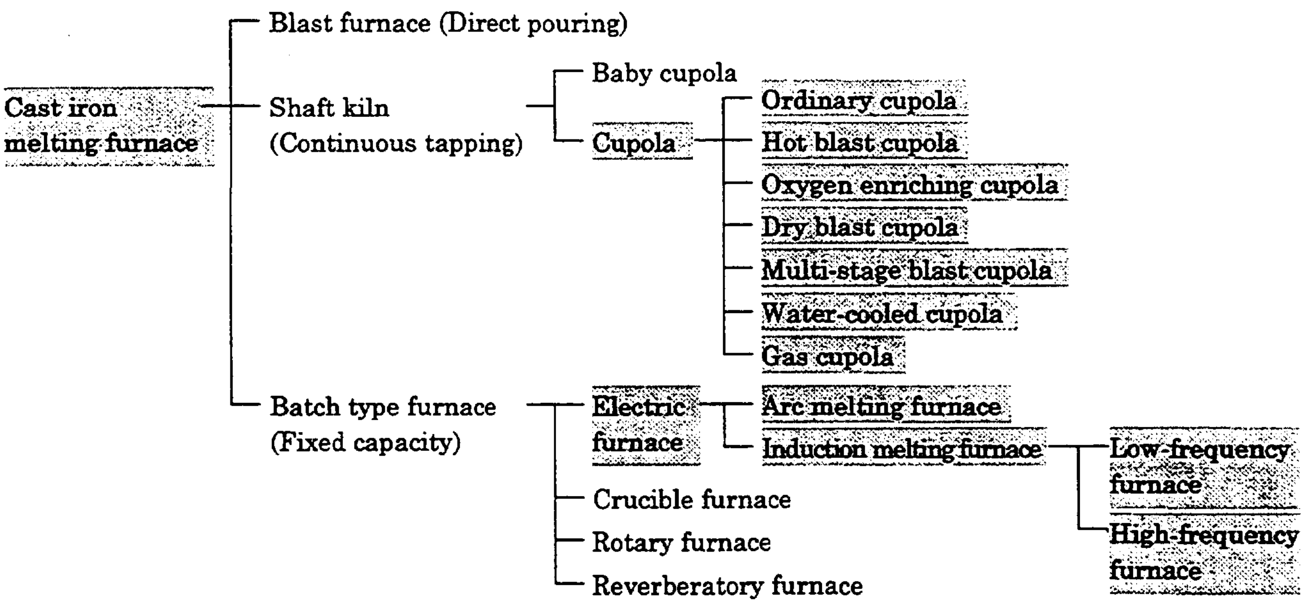


Fig.1 Classification of cast iron melting furnaces

The cupola is a shaft furnace for continuous melting of cast iron with new pig iron, return scrap iron, and steel scrap used as raw materials and coke used as a fuel. A cupola has not only the economic advantage of low equipment cost, but also refining and self-purifying capability, which makes it possible to get excellent molten metal even from inferior-quality raw materials and has been widely used.

However, the exhaust gas from cupola, containing not only carbon dioxide from coke combustion, but also smoke and dust generated coak ash, NO_x and SO_x, causes pollution in the air and working environment.

The use of a solid fuel makes it difficult to manage and control operation, making it difficult to cope with mechanization, personnel saving, and especially lack of skilled workers.

The induction furnace is of the electric heating type, which makes it easy to handle, to control temperature and to adjust chemical compositions. It has an advantage over cupola in its capability to improve the quality of material and ensure the reliability of quality. In addition, since air is not used for heating, loss of metal through oxidation is low, the amount of carbon dioxide and smoke and dust generated is less, which can improve the working environment; and is useful for the protection of the global environment. However, high equipment cost, comparatively high power rates, etc. make the induction furnace have to share the major part of cast iron melting with the cupola.

The arc furnace has developed mainly as a steel melting furnace. In Japan some people say that technical problems arise in melting gray cast iron, and only 3 to 5 per cent of the whole melting process are done arc furnace including the use as a dual melting furnace with a cupola.

2.4.2 Energy conservation in melting

Independent of the kind of melting furnace, the following considerations are necessary for energy conservation in the melting process:

(1) improvement of melting operation;

(2) reduction of heat input;

(3) reduction of heat loss.

Items characteristic of each type of melting furnace will be described in detail later; the following are common ones:

(1) Improvement of melting operation

a) Removal of rust, sand and oil stains from charged scrap

They form slag which need more heat input; they shall be removed by shot blast before charging. In addition, attention shall be paid to the scrap storage to prevent rusting.

b) Reduction in analysis time

To reduce melting time, analysis time shall be reduced as far as possible. To achieve this, it is necessary to put the melting furnace and analysis test place as close to each other as possible and attention shall be paid to rapid and exact communication of the analysis result.

c) Reduction waste time for molding and crane to furnace

Attention shall be paid not to hold molten metal uselessly by mismanaging the tapping timing with mold preparations or by waiting for a crane, etc.

d) Reduction in residual molten metal

The weight of metal cast shall be estimated properly to reduce the amount of residual molten metal.

(2) Reduction of heat input

a) Lowering of temperature of molten metal

To avoid raising of tapping temperature in consideration of temperature loss during pouring and keeping a proper pouring temperature, attention shall be paid to perform preheating of the ladle, to prevent heat radiation using the lid of the ladle, to locate the melting furnace and pouring place as near to each other as possible, and to reduce moving time, etc.

(3) Reduction of heat loss

- Details will be described in each sort of furnace.

3. Cupola melting

3.1 Functions of cupola

A cupola is intended to economically obtain molten metal ensuring castings with few defects, that is,

(1) to produce hot and clean molten metal;

(2) to produce molten metal with high fluidity;

(3) to produce molten metal with proper chemical compositions;

(4) to ensure economical and constant operation and easiness of repair.

To fulfil these functions, the following are necessary:

(1) to design the cupola with proper structure;

(2) to select and use proper charge materials;

(3) to establish and manage proper operating conditions;

(4) to control the inter-process quality properly.

3.2 Structure of cupola

Fig.3 shows the basic structure of a cupola and Table 1 - the standard dimensions of principal parts of conventional cupola. The function of a cupola depends on the part lower than the charging door, which is divided into the preheating zone, the melting zone, the superheating zone, and the well from a functional point of view.

Metal charged through the charging door is first heated in the preheating zone by combustion gas heat of coke, and then melted in the melting zone, followed by being subjected to superheating and tapped from the tapping hole through the trough. In favorable operations, as shown in Fig.2, the furnace temperature is said to be 500 to 1000°C in the preheating zone, 1200 to 1500°C in the melting zone, and 1600 to 1800°C in the superheating zone; it is desirable that the tapping temperature be 1500 to 1550°C. The melting zone and the superheating zone are classified into the deoxidation zone and the oxidation zone from the viewpoint of combustion reaction. In cupola melting, the positions of these deoxidation and oxidation zone are important; they have a great influence on the properties of molten metal. When the oxidation zone is expanded to the top of furnace or solid metal is put in a strong oxidizing atmosphere because of lowering of the metal melt-down position, oxidation of molten metal is accelerated, the melting loss of Si is increased, which may cause the abnormal of graphite form and defects such as shrinkage cavity, etc.

(1) Effective height

The height from the tuyere (lower tuyere in case of a multistage tuyere) to the lower end of the charging door is called "effective height", which is the most important part from a functional point of view. This part, which is a preheating zone where metal and coke are preheated by heat of combustion gas blown up from below and moisture of coke is evaporated, needs enough height, while excessive height may increase blast resistance and cause crushing of coke at the time of charging; it is desirable that it be 3.5 to 6.0 times as large as the inside diameter of the cupola.

(2) Tuyeres

They are blasting ports for combustion air; this is an important part affecting the combustion of coke. Uneven pressure or quantity of air supplied from each tuyere will lead to uneven combustion and heat generation of coke at the tuyere, causing oxidation melting in low-temperature parts, thus generally lowering the temperature of molten metal. There are many researches and patents related to equi-blast such as the form of the tuyere, windbox, buffer plate, etc. The ratio of the total cross section of tuyeres to the cross section of the furnace (tuyere ratio) is 5 to 9 for a small furnace and 10 to 15 for a large furnace.

This is because in the case of a large furnace it is necessary to increase wind speed so that wind will reach the inner part of the furnace. The number of tuyeres should be increased so that there are no dead points where combustion is insufficient; it should be 6 in the case of a small furnace and should be increased with an increase in the size of furnace; tuyeres should be arranged horizontally on a plane at equal intervals, surrounding the furnace.

(3) Windbox

The windbox is intended to convert the kinetic pressure of air to static pressure to make equi-blasting from each tuyere into the furnace . The windbox should be designed so that the velocity head of air passing through the air blast tube will be as small as possible to supply an equal quantity of air to each tuyere.

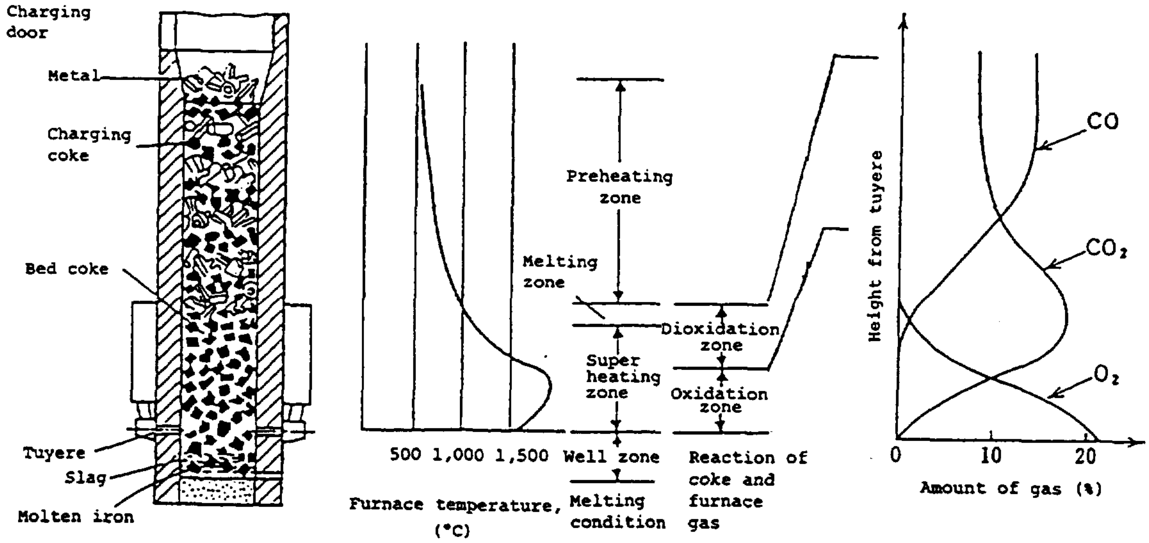


Fig.2 Combustion reaction and gas distribution in cupola

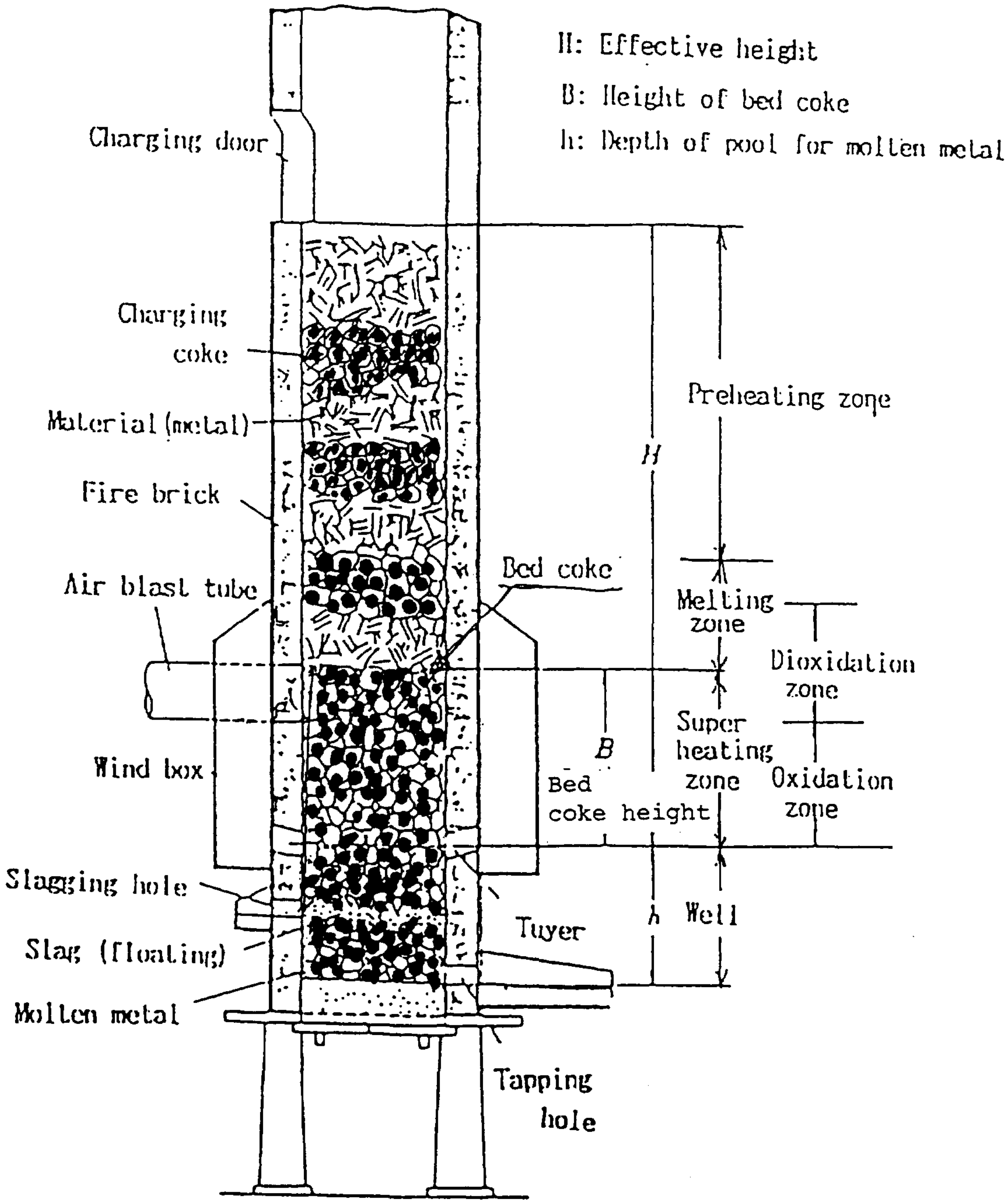


Fig.3 Structure of cupola and functional zones

Table 1 Standard dimensions of principal parts of cupola

Inside diameter of furnace (mm) D	Cross section of furnace (m^2) A	Tuyere ratio A/a	Effective height ratio H/D	Effective height (mm) H	Well depth (mm) Front slagging	Well depth (mm) Fixed receiver	Dimensions of vertical section of wind box (mm) Holizontal	Dimensions of vertical section of wind box (mm) Vertical	Thickness of lining of super heating zone (mm)	Thickness of bottom sand (mm)	Melting speed (t/h)
400	0.126	4 ~ 7	6.0	2,400	400	350	140	560	120	100	0.8
450	0.159	4 ~ 7	6.0	2,700	400	350	150	600	120	130	1.1
500	0.196	4 ~ 7	6.0	3,000	425	350	160	640	120	160	1.4
550	0.237	5 ~ 8	5.8	3,190	425	350	180	720	190	180	1.7
600	0.283	5 ~ 8	5.6	3,360	450	375	200	800	190	200	2.1
650	0.332	5 ~ 8	5.4	3,520	450	375	215	860	190	200	2.5
700	0.385	6 ~ 9	5.2	3,640	475	375	230	920	240	220	2.9
750	0.442	6 ~ 9	5.0	3,750	475	400	250	1000	240	220	3.4
800	0.502	6 ~ 9	4.9	3,920	500	400	270	1080	240	220	3.9
850	0.567	7 ~ 10	4.8	4,080	500	400	285	1140	310	240	4.4
900	0.636	7 ~ 10	4.7	4,230	525	425	300	1200	310	240	5.0
950	0.708	7 ~ 10	4.6	4,370	525	425	320	1280	310	240	5.6
1,000	0.785	8 ~ 11	4.5	4,500	550	425	340	1360	360	260	6.2
1,050	0.865	8 ~ 11	4.4	4,620	550	450	355	1420	360	260	6.9
1,100	0.950	8 ~ 11	4.3	4,730	575	450	370	1480	360	260	7.6
1,150	1.038	9 ~ 12	4.2	4,830	575	450	390	1560	360	260	8.3
1,200	1.130	9 ~ 12	4.1	4,920	600	475	410	1640	430	300	9.1
1,250	1.227	10 ~ 13	4.0	5,000	600	475	430	1720	430	300	9.9
1,300	1.327	10 ~ 13	3.9	5,070	625	475	450	1800	430	300	10.8
1,350	1.431	11 ~ 14	3.8	5,130	625	500	470	1880	430	300	11.7
1,400	1.539	11 ~ 14	3.7	5,180	650	500	490	1960	430	300	12.6
1,450	1.650	12 ~ 15	3.6	5,220	650	500	510	2040	430	300	13.6
1,500	1.766	12 ~ 15	3.5	5,250	675	500	530	2120	430	300	14.7

(4) Blast volume and pressure

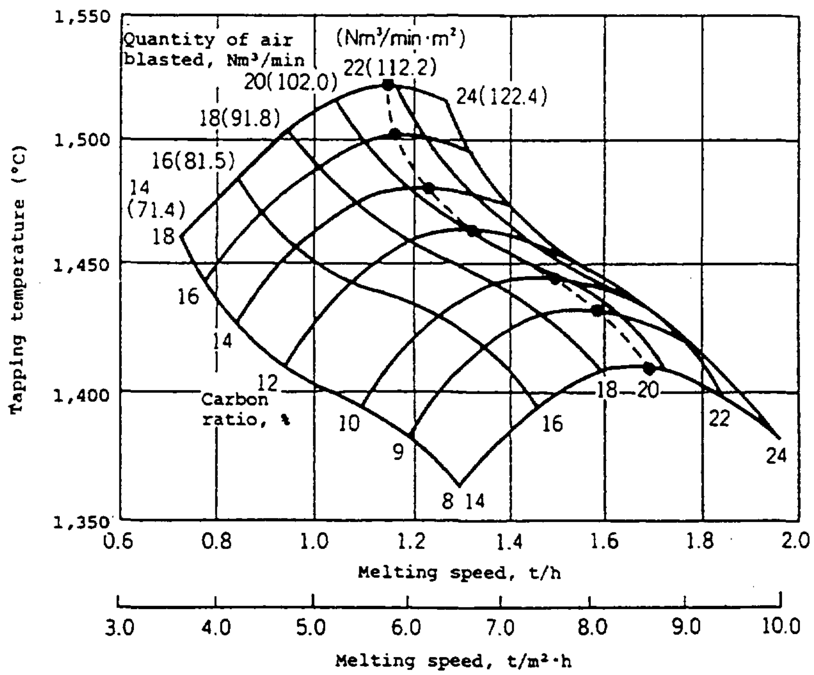
The blast volume and pressure are important to ensure proper operation of a cupola. In Table 2 some examples are given of the relationship between capacity of a cupola, blast volume and pressure. The blast volume should be large enough to supply sufficient oxygen to hold proper combustion and ensure complete combustion of carbon content in coke except that picked up to iron. But if the blast volume is too large it will lower the furnace temperature, leading to oxidation melting, to which attention should be paid. The theoretical air quantity is 7.75 Nm^3/min per 1 kg of coke.

Shown in Fig.4 is the mesh diagram of the relationship between blast volume, carbon ratio, tapping temperature and melting speed. The most effective blast volume is shown by the dotted curve plotted by connecting the highest points of tapping temperature for each carbon ratio. Fig.5 shows the relationship between blast volume and oxidation loss of molten metal. As seen from the figure, oxidation proceeds rapidly when the blast volume exceeds a certain value and oxidation loss increases more sharply as the coke ratio is lowered.

Blast pressure shows resistance by charges in the furnace; pressure shall be changed by the height of the coke bed and particle size of coke, and operation problems such as hanging and clogging of a tuyere shall be controlled by means of wind pressure.

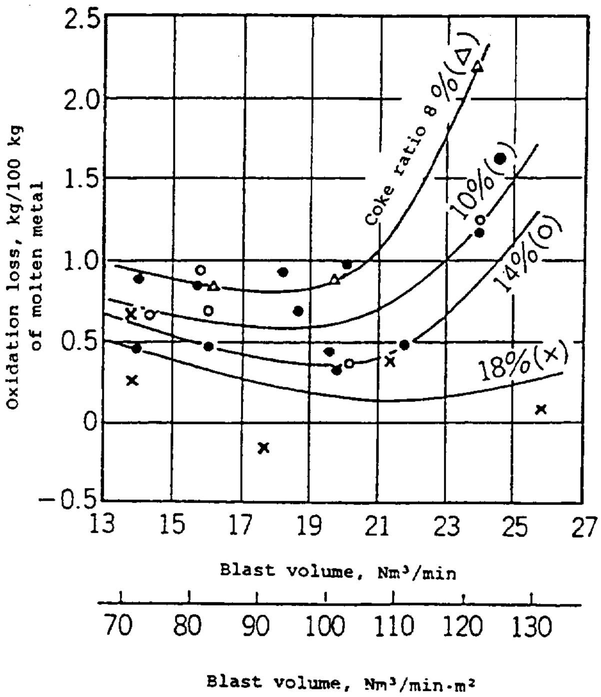
Table 2 Example of cupola blower

melting speed	Specifications of Blower				
	Motor output		Blast volume		Wind pressure
(t/h)	(kW)	(HP)	(m^3/min)	(m^3/min.m^2)	(mm H_2O)
2	22	29.5	40	141	1200
3	30	40.2	60	156	1400
5	45	60.3	80	126	1550



Inside diameter of cupola
: 500mm
Acid, water-cooled operation
Particle size of coke
: 80 to 100mm

Fig.4 Relationship among blast volume, carbon ratio, melting speed, and tapping temperature



Inside diameter of cupola

: 500mm

Acid, water-cooled

operation

Particle size of coke

: 80 to 100mm

Fig.5 Oxidation loss, blast volume and coke ratio

3.3 Melting operation of cupola

(1) Ignition

After the cupola has been repaired and dried, firewood for igniting coke is put on the bottom and ignited. After ignition, bed coke is charged to a specified height and is the burned sufficiently by natural draft.

(2) Fore blowing

As soon as flames reach above the bed coke, the tuyere peep holes are closed and conduct fore blowing is allowed for 3 to 5 minutes, then the height of the bed coke should be adjusted using a chain, a steel bar, etc. from the charging port. The proper height of the bed coke is 1.5 to 1.8 times as large as the furnace diameter for small furnaces up to 700 mm in diameter, and 1200 to 1300 mm for larger furnaces.

(3) Charging of materials

Metallic materials, such as pig iron, scrap iron, steel scrap and ferro-alloys, are mixed in accordance with the pre-determined table and charged into the furnace. It is desirable that a batch of metal charge is about 1/10 of the quantity of molten metal tapped per hour. Then a fixed amount of coke (charging coke) should compensate the loss of bed coke and lime stone of 3 to 4 per cent of metal to increase the fluidity of slag generated during melting. Charging shall be done in the order of coke, limestone then metallic materials and shall be up to just below the charging port. Too much charged materials increase the speed of passage of combustion gas, lowering preheating effect. They may sometimes cause hanging. On the other hand, too little materials prevent ventilation in the furnace, causing incomplete combustion or lowering melting speed. It is recommended that materials charged have the following dimensions.

Coke	1/5 to 1/8 of the inside diameter of the furnace
Metal	1/3 or less of the inside diameter of the furnace and 1/6 or less of the cross section of the furnace
Pig iron, scrap iron	15 kg or less/pc.
Steel scrap	Thickness 25 mm or less

(4) Start of blasting

After the materials have been charged, they should be held, for 15 to 20 minutes to preheat them followed by starting an air blast through the blast tube, windbox, and tuyeres with the use of the air blower to commence melting. Materials on the bed coke are preheated by combustion gas; then melting starts. In 3 to 5 minutes molten metal can be seen through the tuyere dropping in to the bed coke. If it takes less than 2 minutes the bed coke is too low, and if it takes more than 6 minutes the bed coke is too high.

In 15 to 20 min after starting the air blast the tapping hole will be open. Molten metal is heated in the superheating zone and accumulated in the well followed by being tapped through the tapping hole and trough. The temperature of the first molten metal is generally low and is apt to fluctuate in chemical compositions; it is recommended that an initial tap should not be used for qualitatively important products. To get the high temperature molten metal from the beginning, it is necessary to increase slightly the height of the bed coke and to blast excessive air at the initial stage, to add 2 per cent of calcium carbide to the first charging coke, or to perform air blasting with enriched oxygen.

(5) Tapping

Since materials charged in the furnace begin to fall after air blasting is started, coke, metal, etc. shall be supplied at constant intervals so that the furnace will always be filled with raw materials up to just under the charging door. The change in this height will lead to a change in blast pressure, affecting the furnace condition, to which attention shall be paid. Even when operation is conducted with the correct blast volume and coke ratio, the bed coke inevitably becomes lower due to erosion of the furnace wall in the melting zone after being in operation for a long time. To compensate this, it is necessary to add about one charge of coke every 1 to 1.5 hours after operation is started.

When the cupola is working satisfactorily,:

1) the color of the flame of combustion gas in the charging door is light purple or light pink. A yellowish-red flame shows an oxidizing atmosphere;

2) each tuyere is uniformly bright;

3) slag is of good fluidity, glossy, and glassy, light green or whitish, and light; at the time of oxidizing melting, the FeO content is increased in slag and its color becomes blackish, its specific gravity becomes higher, and it loses gloss;

4) molten metal is hot (1530°C or higher) and the break surface figure of molten metal does not appear for a while after poured into ladle.

3.4 Foundry coke

Foundry coke has two roles: an energy source for melting and carbon pick-up agent to iron. Attention shall be paid to the following items when selecting foundry coke:

(1) Particle size

The size of coke is recommended to be 1/5 to 1/8 of the inside diameter of the cupola. The coke particle size has a great influence on ventilation resistance and combustion in the furnace. When the particle size is small, the surface area becomes larger and the oxidation zone just above the tuyeres becomes shorter and hotter, accelerating deoxidation reaction and thus lowering furnace temperature. In addition, the position of the metal melting zone is also lowered, causing lowering of melting temperature. On the other hand, when the particle size is large, the oxidation zone is expanded, making CO_2 deoxidation reaction insufficient; thus generating an atmosphere with a lot of CO_2 in the upper part and causing oxidizing melting.

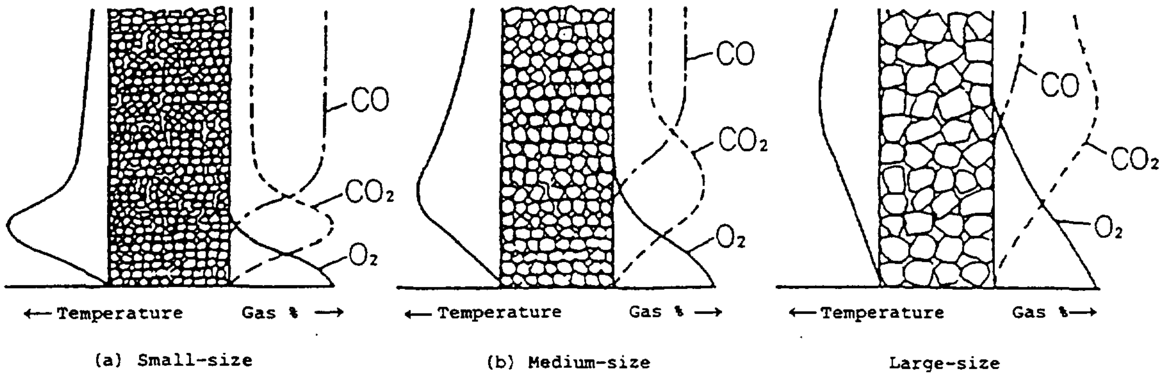


Fig.6 Effects of coke size to combustion in cupola

(2) Coke strength (Shatter index)

When coke strength is insufficient, coke can be damaged at the time of charging in the cupola or during transportation, leading to heavy loss and uneven particle size and causing unstable melting. In Japan, JIS standards specify that the shatter index should be 85 or more (85 per cent or more of coke dropped from a height of 2 m four times remain after sifting with the use of a 50 mm sieve), and in practice coke with a shatter index of 93 per cent or more is supplied.

(3) Porosity

The volume of void spaces in coke is an important factor related to its combustibility and reactivity. High-porosity (low apparent specific gravity) coke can increase melting speed, but lowers tapping temperature. Coke on the Japanese market has an apparent specific gravity of 1.15 to 1.30.

(4) Ash content

When the ash content of coke increases, the amount of fixed carbon decreases. Under the same operating conditions, low ash content coke increases carbon pickup to molten metal, raising tapping temperature. Therefore, in case of small cold blast cupola operation, low ash content coke is often used, while a hot blast cupola, high ash content coke is used from an economical point of view, because blast temperature is high and the influence of ash is reduced.

(5) Sulfur content

Sulfur content of foundry coke should be as low as possible. When molten metal comes in contact with red-hot coke, the sulfur pickup to molten iron occurs and has a very negative effect.

(6) Moisture

Moisture in coke is heated and evaporated in the preheating zone of the cupola, so it apparently has little influence on molten metal. However, the change of moisture content affects the weighing accuracy of charged coke , making proper melting difficult. Therefore, when storing coke, attention should be paid to providing a roof to prevent penetration of rain, to make sure the floor is inclined slightly to prevent formation of puddles, and that there is good ventilation for natural drying.

4. Energy conservation of cupola

4.1 Heat efficiency of cupola

The energy conservation of cupola is evaluated by its heat efficiency. That is:

Heat efficiency = (Heat content of molten metal/Total heat input) × 100.

The heat efficiency is calculated by using the above formula after calculating heat balance by using heat input and heat output obtained for each item per ton of molten metal. Table 3 shows the main items of heat input and heat output. Heat balance is intended for examining heat output in detail to take measures for reducing heat loss, but it is difficult to achieve it only by the foundry from the viewpoint of measuring equipment and technology. The heat efficiency alone can be calculated from the four factors of heat input and sensible heat carried away by molten metal.

Table 3 Factors of heat balance of cupola

	Factors	Remarks
Heat input	1.1 Combustion heat of coke	Lower heating value. Except picked up carbon
	1.2 Sensible heat of blast air	In the case of hot blast
	1.3 Oxidation heat of metal	Oxidation heat of metals, Fe, Si, Mn,
	1.4 Combustion heat of auxiliary fuel	When auxiliary fuel such as heavy oil, gas, carbide, etc. are used
Heat output	2.1 Heat content of molten iron	
	2.2 Heating value of decomposition of lime stone	
	2.3 Heating value carried away by slag	Formation melting and superheating of slag
	2.4 Sensible heat in stack gas	Amount of dry gas + Amount of vapor
	2.5 Combustion heat of in stack gas	CO gas + H_2 gas
	2.6 Potential heat of residual metal	
	2.7 Potential heat of residual coke	
	2.8 Heat content carried away by cooling water	Water cooling of furnace wall and tuyeres
	2.9 Others	Radiation heat from furnace wall, heat reserve by furnace casing

4.2 Calculation of heat input

(1) Combustion heat of coke

To obtain correct combustion heat of coke is difficult, because the inter-reaction of fixed carbon, volatile materials, sulfur, moisture, etc. in coke is complex, and a lower heating value, heat of condensation of water vapor reduced from higher heating value, is used as combustion heat of coke.

Lower heating value $(H_1) = H_h - 6 \times (9 \times h + w)$ (kcal/kg),

Higher heating value $(H_h) = 81 \times C + 340 \times (h - 0/8) + 25 \times S$ (kcal/kg),

where

h: Actual hydrogen content in coke (%)

w: Actual whole moisture at usage in coke (%)

C: Fixed carbon of coke (%)

O: Oxygen of coke (%)

S: Sulfur of coke (%).

Since in a cupola coke is consumed not only for combustion but also carbon pickup, the amount of coke practically burned is obtained by subtracting the amount of coke consumed for picking up from the total amount of coke used.

The amount (W) of coke burned per 1t of molten metal is:

$$W = (W_1 - W_2)/T,$$

where

W_1: Total amount of coke used (kg)

W_2: Amount of coke consumed for carbon pickup (kg)

T : Total amount of molten metal (t)

The heating value (Q_1) of coke per 1t of molten metal is:

$$Q_1 = W \times H_1.$$

(2) Sensible heat in air blast

The sensible heat (Q_2) in air blast per ton of molten metal is:

$Q_2 = L_0 \times C_{air} \times (T_{air} - T_r)$,

where

L_0: Quantity of air blasted per ton of molten metal (Nm^3)

C_{air}: Mean specific heat of air ($kcal/Nm^3 \cdot °C$) ... Usually 0.321 $kcal/Nm^3 \cdot °C$

T_{air}: Air blasting temperature (°C)

T_r : Ordinary temperature (°C)

(3) Oxidation heat of metal

In cupola melting, the oxidation heating values of Fe, Si, and Mn are calculated.

$Fe + (1/2)O_2 = FeO + 898$ kcal/kg

$Si + O_2 = SiO_2 + 7406$ kcal/kg

$Mn + (1/2)O_2 = MnO + 1760$ kcal/kg

The heating value (kcal/t) by oxidation of these elements is calculated from oxidation losses of ΔFe, ΔSi, and ΔMn (kg/t) per 1t of molten metal as follows:

$Q_3 = 898 \times \Delta Fe + 7406 \times \Delta Si + 1760 \times \Delta Mn$.

(4) Combustion heat value of auxiliary fuel

Heavy oil, gas, carbide, etc. are as used sometimes as auxiliary fuel of cupola. The combustion heat of auxiliary fuel (Q_{sup}) per ton of molten metal is calculated from the weight (W_{sup}) kg of auxiliary fuel used per 1t of molten metal, the amount of gas (L_{sup}) Nm^3, the heating value of each of them (H_{sup}) kcal/kg or kcal/Nm^3 as follows:

$Q_4 = W_{sup} \times H_{sup}$ or $Q_4 = L_{sup} \times H_{sup}$

4.3 Calculation of heat output

(1) Heat content carried away by molten metal

The heat content of molten metal is calculated based on the material and temperature. The heat capacity of each element in Table 4 is calculated from the temperature followed by integrating them according to their percentage in the material.

Table 4 Heat capacity per ton of each element

Metal element	Heat capacity (kcal/t × 10^3)		
	1400°C	1500°C	per 100°C
C	533.2	580.5	47.3
Si	725.8	751.6	25.8
Mn	313.0	332.0	19.0
Ni	258.0	274.3	16.3
S	222.7	239.9	17.2
Fe	298.4	315.6	17.2

(Example) Gray cast iron

C	3.3%
Si	1.9%
Mn	0.6%
S	0.07%
Fe	94.2%

The heat capacity (Q) of molten metal per ton with a temperature of 1550°C can be calculated in the following way:

$$
\begin{aligned}
Q &= (580.5 + 47.3 \times 50 / 100) \times 0.033 \\
&+ (751.6 + 25.8 \times 50 / 100) \times 0.019 \\
&+ (332.0 + 19.0 \times 50 / 100) \times 0.006 \\
&+ (239.9 + 17.2 \times 50 / 100) \times 0.0007 \\
&+ (315.6 + 17.2 \times 50 / 100) \times 0.942 \\
&= 342.1 \quad (\text{kcal/t} \times 10^3)
\end{aligned}
$$

From the description above, the heat efficiency of a cupola is expressed as follows:

Heat efficiency = (Heat content carried away by molten metal/Total heat input) × 100

$$= \{Q_m / (Q_1 + Q_2 + Q_3 + Q_4)\} \times 100.$$

4.4 Heat balance diagrams and heat efficiency of a cupola

Fig.7 shows examples of heat balance of cold blast operation and 300°C and 600°C hot blast operation of a cupola with an inside diameter of 650 mm. The heat efficiencies are 32.4 per cent, 51.8 per cent, and 60.0 per cent, respectively.

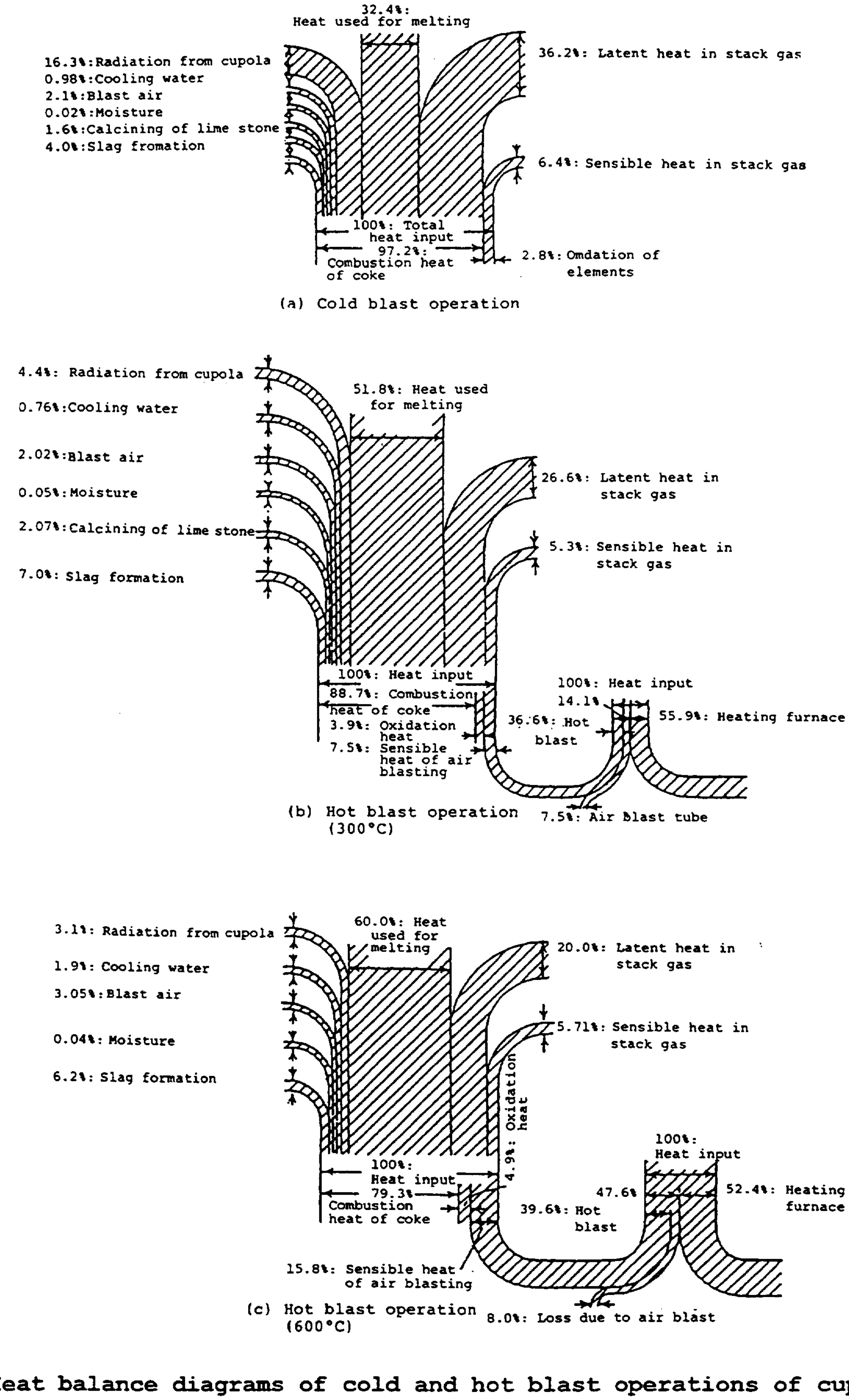


Fig.7 Heat balance diagrams of cold and hot blast operations of cupola

5. Improving the heat efficiency of a cupola

5.1 Hot blast cupola

5.1.1 The purpose of hot blasting

The temperature of exhaust gas of a cupola is as high as 800°C, making it possible to preheat blast air up to as high as 400°C by heat exchange. In addition, both the sensible and latent heat of exhaust gas can be recycled for preheating blast air by combustion of CO gas included in exhaust gas.

When blast air is preheated to 300°C or higher, the sensible heat of blast air is added to heat input, activating combustion of coke, leading to the rise in combustion temperature (Fig.8), thus improving heat efficiency and economy owing to the reduction in the coke ratio and increase in melting speed. Moreover, in the upper part of the combustion zone, CO_2 gas due to coke is deoxidized by high temperature, realizing a highly reductive atmosphere, thus decreasing the oxidation loss of metal. In cold blast operations, combustion is hindered around tuyeres by cold air, while in hot blast operations, the maximum temperature zone comes down just above tuyeres (Fig.9).

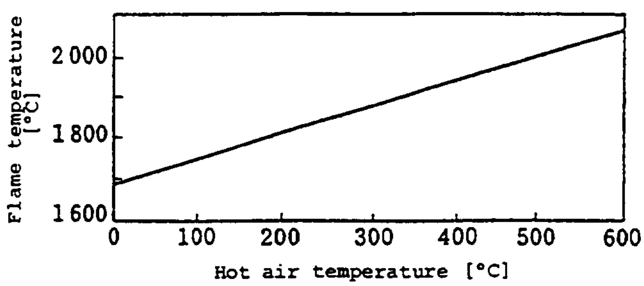


Fig.8 Hot air temperature and coke flame temperature

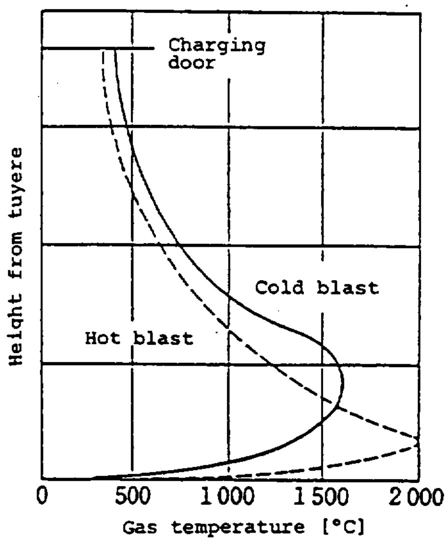


Fig.9 Furnace temperature distribution in cold blast and hot blast operation

Hot blast

i) reduces the coke ratio, improving the heat efficiency (See Fig.7);

ii) raises tapping temperature, improving the quality of molten metal;

iii) increases melting speed, increasing melting capacity;

iv) increases the percentage of steel scrap in charge metals due to the increase in carbon pickup and CE value, improving quality of the material and reducing the material cost;

v) ensures little loss of Si and Mn in molten metal in a reductive atmosphere, saving ferro-alloys' cost.

vi) reduces sulfur pick up to iron, improving the quality of material;

vii) lowers the temperature of exhaust gas, reducing the equipment and power cost due to miniaturization of a dust collector.

5.1.2 Hot blast equipment

(1) Furnace wall heat recovery type: Blast air is preheated by the sensible heat of exhaust gas by double wall of the furnace or using a sleeve. This is often used in a small cupola even today.

(2) Stack gas heat exchange type: Preheating blast air is performed by using the sensible heat of exhaust gas of the stack.

(3) Utilization of the latent and sensible heat of exhaust gas: Exhaust gas is sucked in just below the material charging port to utilize both the latent and sensible heat of exhaust gas. Exhaust gas is taken out of several suction ports, led into the combustion chamber followed by mixing with air and ignited. Then the burnt gas is controlled to a set temperature of about 1000°C, led to heat exchanger. Stable hot

air with a temperature of 400 to 600°C can be obtained with 10 per cent or more of CO gas content in stack gas.

5.2 Oxygen enriching cupola

5.2.1 The purpose of oxygen enrichment

Oxygen necessary for combustion of coke is no more than 21 per cent of air; nitrogen occupying 79 per cent of air absorbs heat in the furnace and carries away a lot of heat as stack gas.

Oxygen enrichment is intended to increase the concentration of oxygen during air blasting to raise tapping temperature easily at the beginning of operation or at any melting condition and to increase melting speed.

Table 5 shows some examples of oxygen enrichment.

The following are advantages of oxygen enrichment:

i) Raise tapping temperature, improving the quality.

ii) Increase melting speed and melting capacity.

iii) Decrease blast volume and save power.

iv) Reduce coke ratio and improve heat efficiency.

v) Increase steel scrap in charge and improve the quality of material and reduce the material cost.

vi) Improve the yield of Si and Mn, and reduce fello-alloys.

vii) Reduce S pickup to iron, and ensure easy treatment of molten metal such as inoculation.

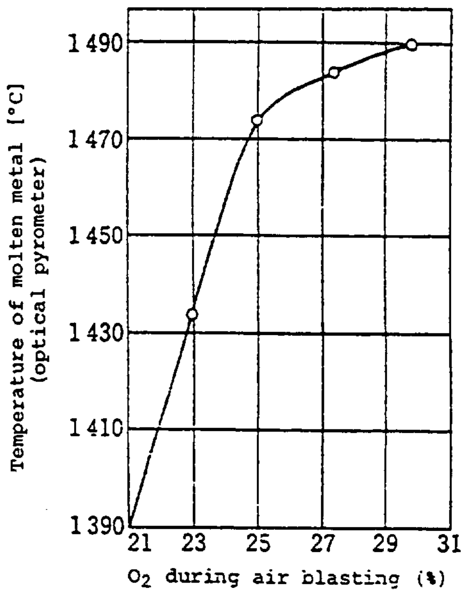


Fig.10 Amount of oxygen and tapping temperature

Table 5 Effects of oxygen enrichment

Inside diameter of cupola	Oxygen enrichment method	Melting speed (t/h)		Coke ratio (%)	
inch (mm)	(amount of oxygen added, %)	Before	After	Before	After
40 (1,014)	Enrichment (2.5%)	6	8	14	12
36 (912)	Enrichment (3.0%)	4	5	15	10
46 (1,166)	Enrichment (4.0%)	10	12	12.5	9.4
48 (1,216)	Injection (3.0%)	7	7	12.5	9.4
32 (811)	Enrichment (2.0%)	2.5	2.5	17	14

5.2.2 Oxygen enriching equipment

Though a method using an oxygen enrichment membrane has also been developed recently, generally pure oxygen produced by evaporating liquid oxygen is added through inserting duct in the air blast tube. Oxygen is diluted with blast air and enriched uniformly to 22 to 25 per cent blasted through tuyeres. The latter method is common and easy adjustable, it is used both continuously or intermittently. In addition, there is also injection procedure blowing oxygen into the furnace through ducts installed in tuyeres.

5.2.3 High-efficiency cupola with high-rate oxygen enrichment

The amount of oxygen enrichment is generally up to 4 per cent, and it is said that enrichment exceeding this value can cause oxidation of molten metal. However, high rate oxygen enrichment can increase the heat efficiency of a cupola up to 35 to 40 per cent, which has been difficult for a small cupola, making it possible to produce a cupola ensuring high-quality molten metal by high-temperature tapping and capable of varying the melting speed in the range 60 to 200 per cent of a rated value. This cupola, ensuring both energy conservation and flexible operation, was commended as excellent energy saving equipment by Japan Machinery

Federation. This cupola can be produced both newly and by modifying an existing one.

5.3 Humidity control cupola

5.3.1 The purpose of humidity control of blast air

High moisture content of the blast air in cupola melting comes in contact with coke, causing the following reaction.

$$H_2O + C = CO + H_2 - 123 \text{ kJ/mol}$$

$$2H_2O + C = CO_2 + 2H_2 - 81.1 \text{ kJ/mol}$$

The upper reaction progresses at a temperature of 1000°C or higher and the lower reaction - at a temperature below 1000°C. Both of them are endothermic, and the temperature adjacent to the tuyere drops. The condition of combustion and heating in the furnace becomes worse. The experiment has shown that tapping temperature sharply lowers at an absolute humidity of 15 g/m^3 or more, the material and becomes inferior melting speed reduces.

Furthermore, moisture in blast air increases oxidizing metal in the furnace, causing adverse influence such as lowering of carbon pickup, and yield of silicon, etc. To cope with cupola operation in a high humidity period, the height of the bed coke is generally increased or the coke ratio is increased in amounts of 1.5 to 2.0 per cent. But this is not desirable from the viewpoint of energy conservation.

By controlling humidity:

i) reduction in the amount of coke used, ensuring energy conservation;

ii) easy quality control for molten metal by keeping stable air low humidity in blast all the year round, reducing defective ratio of castings;

iii) reduction in the material cost due to increase in the percentage of steel scrap in charge;

iv) rise in the temperature of the first tap molten metal and increase in tapping temperature, etc.

But in Japan, where there is a remarkable fluctuation of humidity in a year, the absolute humidity in the dry season is 4 to 6 g/m^3, while in the wet season it is 18 to 24 g/m^3, that is, the difference between them is no less than 20 g/m^3. In a cupola (about 3 t/h) operation with blast volume of 60 m^3/min, water in blast air changes at a rate of as high as 1.2 litre/min. Though the improvement of the heat efficiency is an effective achievement, stable quality is the greatest energy conservation effect of humidity control operation.

5.3.2 Dehumidification equipments

i) Dehumidification with equipment hygroscopic materials

This type equipment is using silica gel, activated alumina, calcium chloride or lithium chloride as moisture adsorbents. Equipment is necessary for drying by heating and reclaiming absorbent materials when they have lost their power through long time use.

ii) Refrigeration

This type of equipment removes excess moisture by cooling air under a dew point to condense. Cooled air is heated by a reheater and supplied to the cupola. The refrigerator type has become popular today by the improvement of the capacity of a refrigerator and measuring and controlling technology to keep humidity constant.

5.3.3 Effects of humidity control

In humidity control operation of cupola, tapping temperature rises and the coke ratio is reduced. Fig.11 shows a refrigerator type dehumidifier capable of keeping the absolute humidity at about 6.5g/m^3 all the year round.

Fig.12 shows how the coke ratio was reduced by this operation.

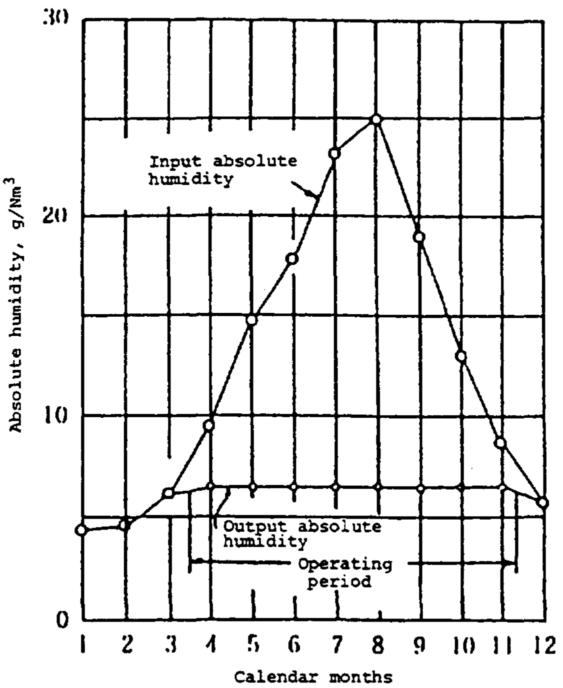


Fig.11 Effects of refrigerator type dehumidifier

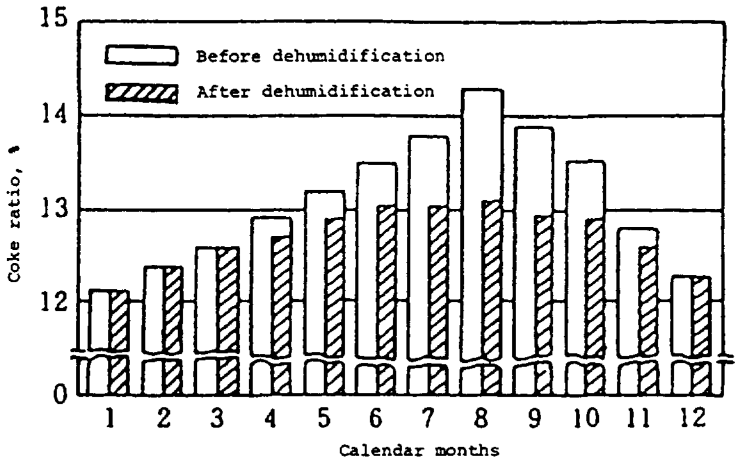


Fig.12 Reduction of coke ratio by humidity control dehumidification

5.4 Multi-stage air blasting cupola

5.4.1 Purposes of multi-stage air blasting cupola

There are two points of view as shown below: Secondary air blast is provided above the main tuyere to burn CO gas coming up in the deoxidation zone and to use the combustion heat for:

(1) metal preheating in the preheating zone is enhanced; or

(2) the melting zone is expanded, the melting position is raised a little, the falling distance of molten drops is increased, and furnace temperature is raised to increase melting and superheating effect.

Nowadays upper tuyeres are often provided in the coke bed for the latter purpose.

5.4.2 Multi-stage air blasting type

In a multi-stage blasting cupola the position of the upper tuyere and ratio of blast volume of the upper and lower tuyeres are to be determined according to the purposes.

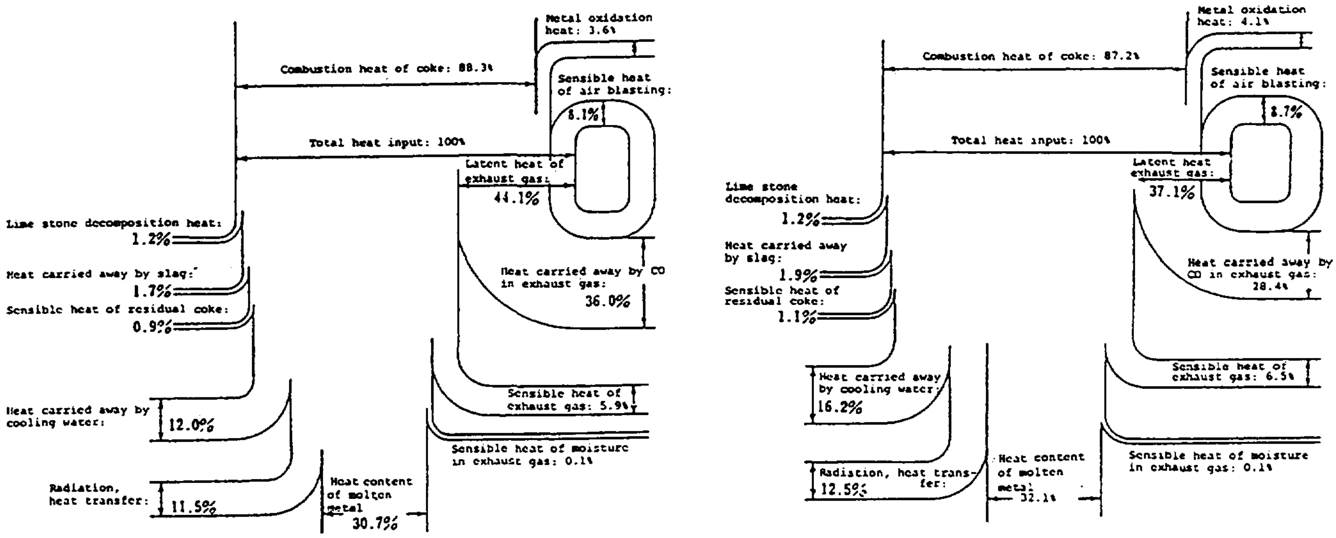
(1) When preheating solid metal, upper tuyeres should be provided in places at a distance of 2 to 3 times the furnace diameter from lower ones, and the blast volume of them may be 15 per cent of the total volume, when the amount of CO gas in flowing gas in the preheating zone is estimated to be 13 to 15 per cent.

(2) When expanding the melting zone and ensure sufficient superheating of molten drops, upper tuyeres should also be provided in the coke bed; they shall be at a height of 1.0 to 1.2 times the furnace diameter from level of lower tuyeres. The blast volume through upper tuyeres is considered adequate to be equal as lower ones.

5.4.3 Effects of multi-stage blasting

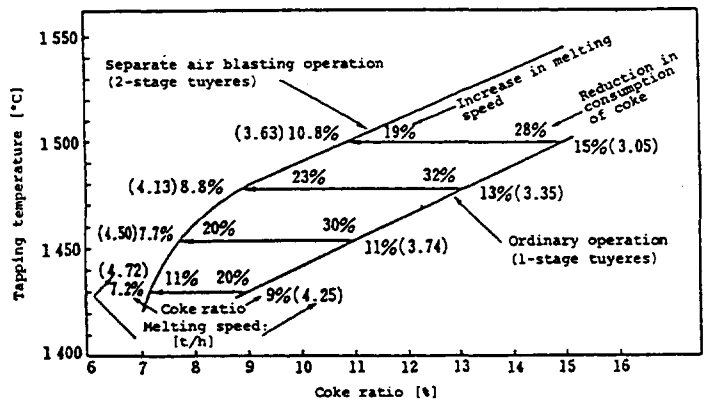
Fig.13 shows heat balances for a large hot blast water cooled no lining cupola with the inside diameter 2300 mm where the upper tuyeres are provided whose total area is half of the main tuyere and at a height of 750 mm above the lower tuyeres. It is reported that the percentage of steel scrap in charge and the yield of C, Si are increased, while the heat efficiency is improved only by 1.4 per cent.

Fig.14 is a diagram illustrating the effect of multi-stage blasting cupola by British castings association. The reduction in the coke ratio and the increase in melting speed to obtain the same tapping temperature are compared for ordinary operation and dual stage blasting. This figure shows remarkable energy conservation and improvement of productivity.



Ordinary blasting   Dual blasting

Fig.13 Comparison of heat balance for ordinary and dual blasting



Inside diameter of cupola:760mm

Total amount of air blasted:43m^3/min

Blast volume ratio of dual tuyeres:

1:1

Fig.14 Change in coke consumption and melting speed for dual blasting operation

5.5 Water cool cupola

5.5.1 Purposes of water cooling of furnace wall

As the size of cupola increases, the number of no-lining hot blast water cool cupolas having only anouter casing made of steel plate without lining in the melting and superheating zones and water shower cooling and preheating hot blast combined, has also been increasing, which ensures longtime continuous operation.

i) Longtime continuous operation reduces the percentage of heat loss necessary for one operation in fixed amounts, improving the heat efficiency.

ii) There is no change in the furnace inside diameter due to errosion of refractories in the melting zone, stabilizing the condition of the furnace.

iii) There are no restrictions on kind of refractories, ensuring normal operation for a long time.

iv) Refining of molten metal is possible by arbitrary change from acidic to basic operation.

v) It is possible to reduce the refractory cost, improve productivity, and realize energy saving.

In the case of a small cupola, since too great a cooling effect adversely affects the condition of furnace and properties of molten metal, it is impossible to realize a cupola having the melting zone without lining.

The same effect as a large cupola can be expected by using high quality refractory (SiC family) in melting zone with jacket or water shower cooling, by water cooled tuyeres projected into furnace which enable the combustion to proceed at the center of furnace, and by banking operation for intermittent melting operation.

5.5.2 Examples of improvement of heat efficiency due to longtime continuous operation (Energy conservation case report, 1991 edition)

(1) Reasons for taking measures

At this plant melting was performed in a low-frequency induction furnace, but the galvanized zinc steel plates for automobiles is increased in steel scraps, which cause worse working environment and Zn content exceeds the allowable limit of 0.06 per cent in molten metal 0.06 per cent for induction furnace, increasing the amount of expensive pig iron and the cost of charge. To cope with this situation, a cupola was introduced to improve the heat efficiency. Fig.15 shows the state of energy use before taking measures.

(2) Measures taken

(a) Tapping hole (patent pending)

The life of refractories of a cupola depends on the abrasion of the tapping hole. A method of replacing this from outside the furnace in hot condition was established, achieving longtime continuous operation for 20 weeks; until then bottom drop down had been performed after 4 day operation for repair. The energy efficiency has been improved by 1.5 per cent.

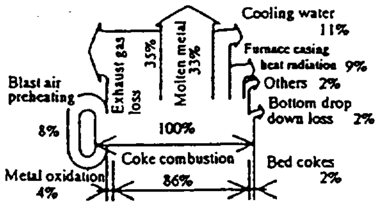
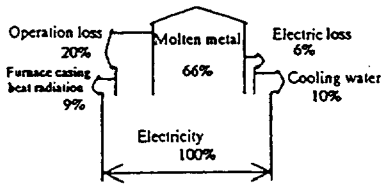
<table>
<tr><td colspan="2"></td><td>Conventional cupola</td><td>Low frequency induction furnace·</td></tr>
<tr><td colspan="2">Melting energy</td><td>Cokes</td><td>Electric power</td></tr>
<tr><td colspan="2">Heat balance</td><td>
</td><td>
</td></tr>
<tr><td colspan="2">Heat efficiency</td><td>33%</td><td>66%</td></tr>
<tr><td rowspan="2">Remarks</td><td>Consumption rate in crude oil-equivalent</td><td>0.09 kl/t</td><td>0.15 kl/t</td></tr>
<tr><td>CO_2 generating quantity</td><td>106c kg/t</td><td>103c kg/t</td></tr>
</table>

Fig.15 Comparison between conventional cupola and low-frequency induction furnace

(b) Improvement of heat exchanger, others

The hot blast temperature is raised from 450°C to 600°C by improving the material and construction of the exhaust gas heat exchanger. The heat efficiency has been improved by 3 per cent. Air blast dehumidification was also performed and warm water was utilized for heating.

(3) Effects of measures

Table 6 Summarized results of measures taken

( ): heat efficiency %

	Low-frequency furnace	Conventional cupola	Cupola after taking measures
Melting efficiency (%)	66	38 (33)	46 (39)
CO_2 discharge (C·kg/t)	103	106	85

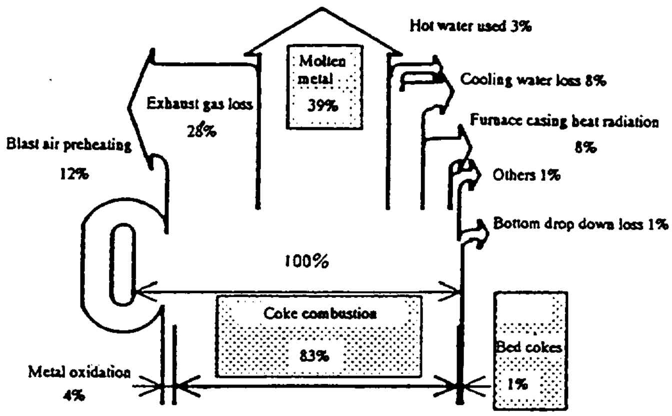


Fig.16 Heat balance of cupola after taking measures

5.6 Improvement of heat efficiency by synergetic effect of air blast conditions

5.6.1 Background of experiment

Cupola operating techniques have been developed one after another and it is difficult to correctly judge the synergetic effect of combinations of these techniques. In this experimental operation the effect of combinations of a cupola with air blast conditions was checked. In particular, there are few experimental operations for a small cupola. These will be a guideline for energy conservation and improve properties of molten metal of cupola for the medium and small foundries.

5.6.2 The contents of experiments

Experiments were performed by using a 2T/H cupola under the following five conditions:

(1) Cold blast + Non-dehumidification

(2) Cold blast + Dehumidification

(3) Hot blast + Dehumidification

(4) Oxygen enrichment + Dehumidification

(5) Hot blast + Oxygen enrichment + Dehumidification

Air blasting conditions are:

Humidity conditions	: 20 g/Nm^3 → 10 g/Nm^3
Hot air temperature	: 350°C
Oxygen enrichment	: +4% (25%)

5.6.3 Experiment results

It was possible for a small cupola to remarkably improve the heat efficiency by reducing the coke ratio and improving the melting speed through humidity control, oxygen enrichment and hot blast or combinations of them. In addition, advantages of increasing carbon pickup in molten metal were also confirmed, such as reduction in the percentage of pig iron in charge, improvement in the yield of material melted, rise in tapping temperature, etc.

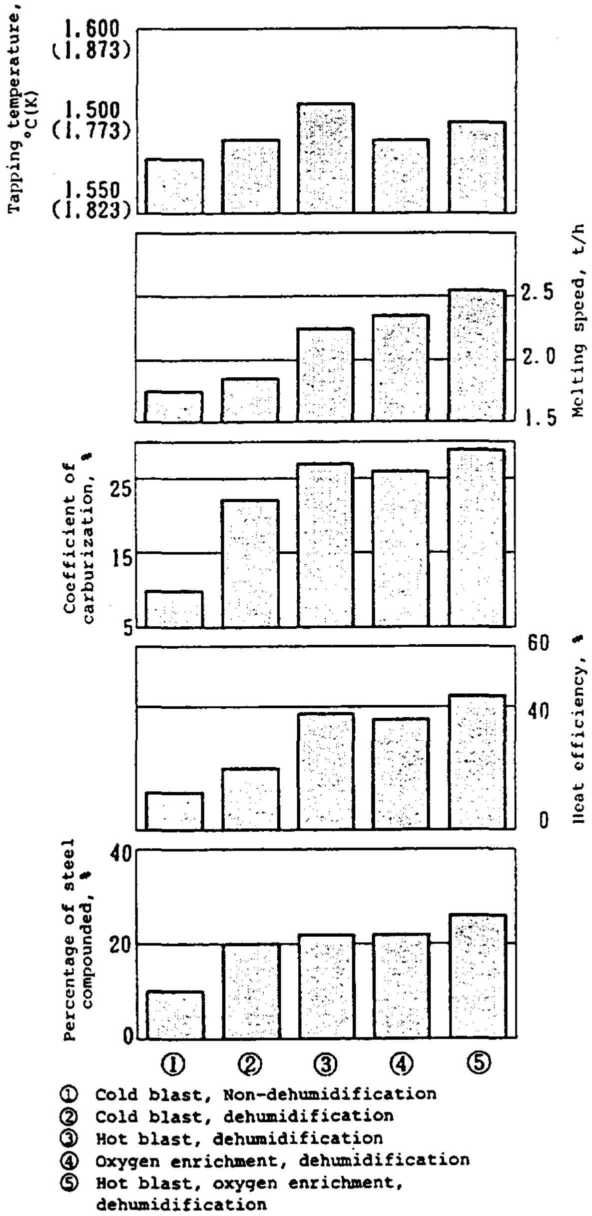


Fig.17 Results of operation of high-efficiency small cupola

5.7 Examples of improvement in properties of molten metal by measurement control of a cupola

5.7.1 Background of taking measures

Molten metal of malleable cast iron is made by means of dual melting of a 15 T/H hot blast cupola and a low-frequency induction furnace. A cupola has the advantage of low melting cost, but has a lot of factors affecting the melting condition, and its operation requires great skill. The melting condition was measured to ensure stable properties of molten metal and energy conservation.

5.7.2 Measures taken

(1) Leveling of the height of charging material

Uneven height of charging material causes uneven blast air resistance, that is, it prevents equi-blasting, adversely affecting properties of molten metal. Attention was paid to the correlation between the ambient temperature of the preheating zone of a cupola and the difference in height of charging material. Temperature was measured in 6 places around the preheating zone as shown in Fig.18 to minimize the difference in height of charging material.

At the time of starting of measurement, the difference in ambient temperature was no less than 250℃ and the difference in height of charging material was 400 mm. To cope with this situation, charging equipment were improved as shown in Fig.19.

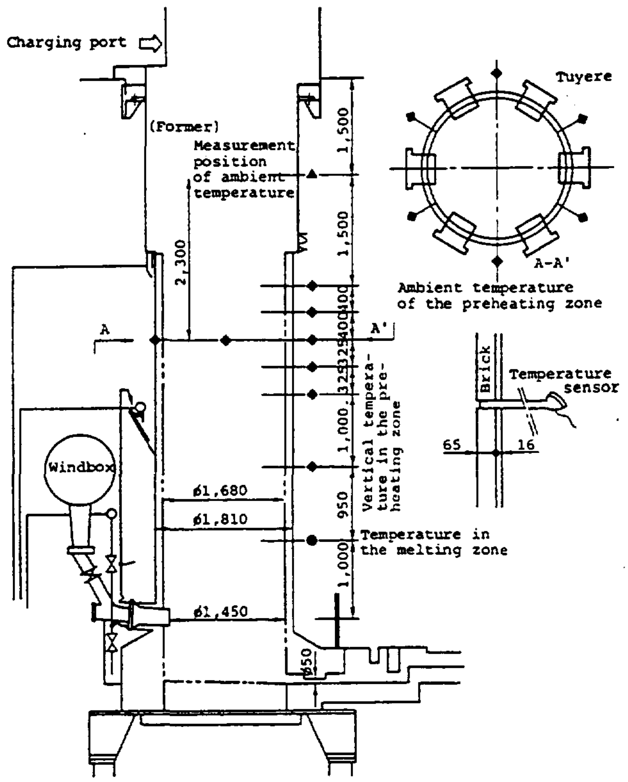


Fig.18 Temperature measurement position and method

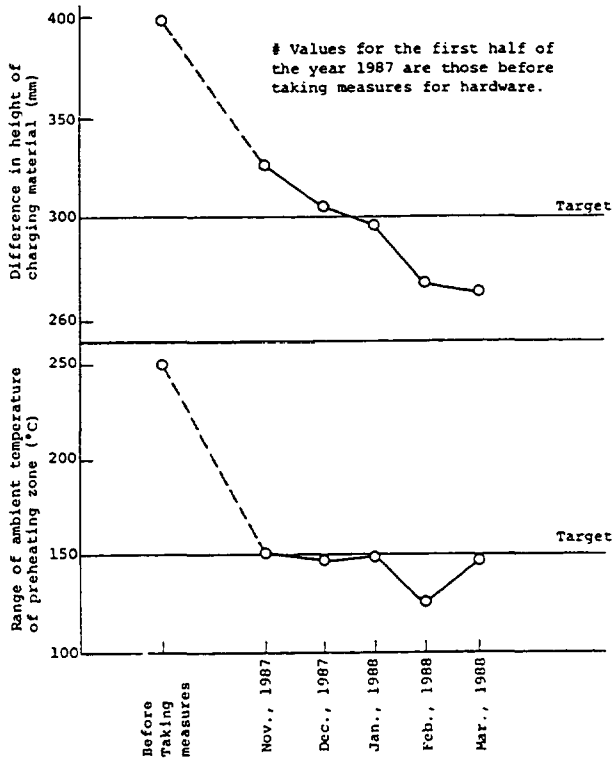


Fig.19 Effects of improvement of material charging apparatus

(2) Estimation and management of bed coke height

In cupola melting, the positions of the oxidation zone and the deoxidation zone are important. The height of bed coke is a factor to manage them. However, it is difficult to directly measure the height of bed coke and the following two indirect factors are used for estimation of the height.

i) Estimation by continuous measurement of Si loss

As a result of high-temperature melting, deoxidation of Si_2O progresses, improving the yield of Si. The height of bed coke is estimated by calculating and displaying Si loss from charge Si and analysis of Si in molten iron, after correcting time lag.

ii) Estimation based on vertical temperature measurement in the preheating zone

Temperatures measured in 6 places arranged vertically in the preheating zone changed in accordance with the change of the furnace condition, which was effective in estimating the height of bed coke. It is possible to grasp the change of the furnace condition earlier than the melting operator judges it by tapping temperature, ensuring stable operation.

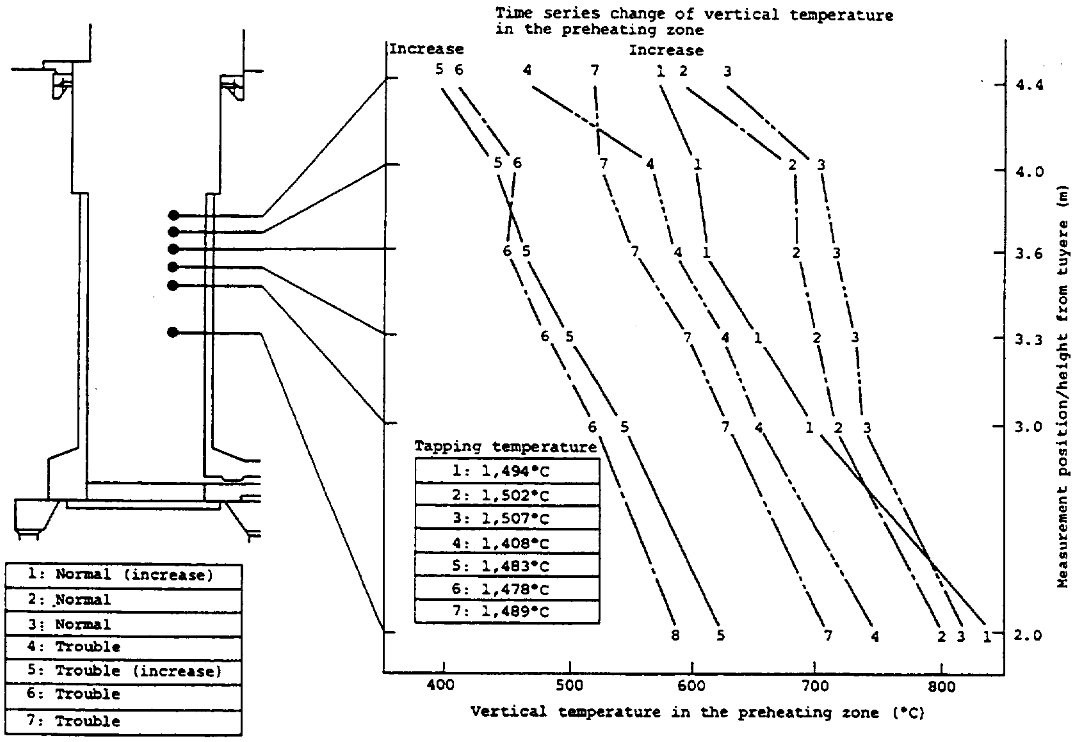


Fig.20 Time series change of vertical temperature in the preheating zone

5.7.3 Effects of measures taken

(1) The fluctuation of tapping temperature has become smaller and tapping temperature increased by 5°C on average, remarkably reducing the power consumption rate of a low-frequency induction furnace.

(2) The fluctuation of molten metal chemical compositions has become smaller and the amount of residual oxides such as Si_2O, MnO, etc. in molten metal has become smaller, reducing casting defects as shown in Fig.21.

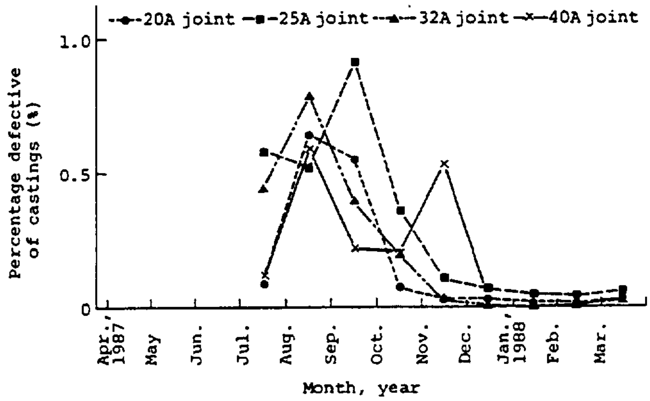


Fig.21 Reduction of casting defects by improvement of properties of molten metal

6. Natural gas cupola

6.1 The structure of a natural gas cupola

An example of a cokeless cupola which uses natural gas as an alternative fuel of coke is introduced. This is a shaft furnace having a cylindrical steel plate lined with refractory, the same as a coke cupola. It has no tuyeres, but instead has a grate of water cooled pipes in the middle stage and natural gas burners under it. Fig.22 shows a schematic structure of a shaft furnace using natural gas.

(1) Melting capacity: 6t/hr; Furnace inside diameter: 1000 mm

(2) Preheating zone

The furnace has an effective height ratio of 4.8; which has enough capacity for storing and preheating charging material sufficient for about one hour of melting, considering effective use of heat.

(3) Heat regenerative material bed and water cooled grate

The bed consists of ceramic balls with a diameter of about 150 mm laid in 2 to 3 layers.

These balls are made of refractory materials having high-temperature strength capable of standing the melting loss against slag at high temperatures and the impact and weight of falling of charging material. A water cooled grate of steel pipe welded construction is used to support the weight of this bed and melting material and the impact load of falling of charged material.

(4) Combustion zone

Three natural gas burners each with capacity of 1.5 million kcal are installed at intervals of 120° to achieve a melting efficiency of 55 per cent. To ensure a balanced amount and pressure of combustion air supplied to each burner, a windbox having a sufficient sectional area is provided. Oxygen enrichment is also possible. Furnace temperature in the combustion zone reaches 1600 to 1650°C; combustion gas heats ceramic balls, melting and superheating raw materials. Water cooling is performed by shower to cool refractories of the furnace wall. Fig.23 shows an operation scheme.

(5) Well

The well located under the combustion chamber has a tapping hole diameter as large as 150 to 150 mm to prevent the tapping hole from being clogged with ceramic balls worn and dropped through the grate.

(6) Low-frequency induction furnace

With operation cost taken into account, molten metal tapped at low temperature of 1350°C is subject to adjust carbon and other element content and to superheat in a low-frequency induction furnaces. There are two low-frequency induction furnaces provided, each of which has a capacity of 3000 kg and an input of 600 kW-1000V. Their temperature raising capacity from 1350°C to 1500°C is 8.5 t/h (71 kWh/t).

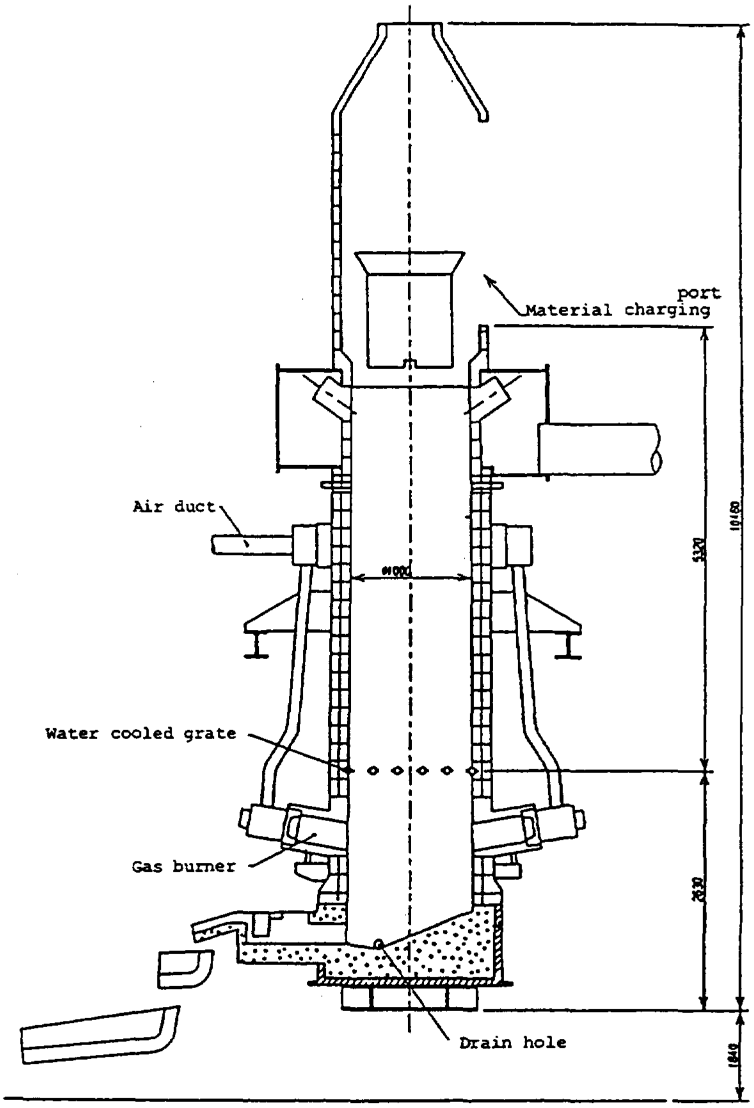


Fig.22 Structure of natural gas cupola

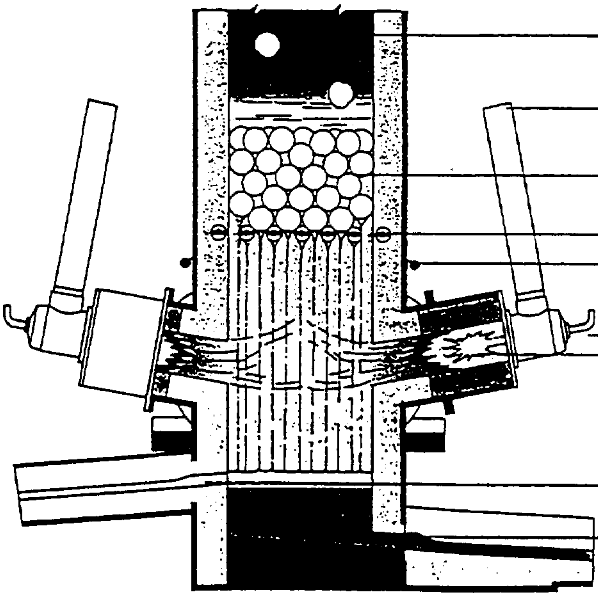


Fig.23 Operation scheme of natural gas cupola

6.2 Comparison of melting energy

Table 7 shows the heat balance of a natural gas cupola in a steady state. In the case of this furnace, preheating is performed before melting in a steady state; the longer the continuous melting time is in relation to the preheating time, the higher the heat efficiency. When preheating and melting are performed for 72 minutes and 9 hours, respectively, the heat efficiency will be 51 to 52 per cent.

Table 7 Heat balance table of natural gas cupola (%)

Gas combustion	Potential heat of molten metal	Potential heat of exhaust gas	Potential heat of cooling water	Potential heat of slag	Others
100	56.3	15.0	14.8	4.9	9.0

Tables 8 and 9 show heat balances including electric power of low-frequency induction furnace for superheating and adjustment and electric power used for motive power of cupola. Standard examples of a coke cupola and a low-frequency electric induction furnace are shown for reference. From the viewpoint of energy consumption, the natural gas cupola is the most earth-friendly of these three melting methods.

Table 8 Energy used in each melting furnace and their heat efficiency (Electric power: directly input)

Kind of energy	Unit	Heating value (kcal)	Gas cupola		Coke cupola		Electric induction furnace	
			Energy consumption /ton	Energy (kcal/ton)	Energy consumption /ton	Energy (kcal/ton)	Energy consumption /ton	Energy (kcal/ton)
Natural gas	Nm^3	9,950	60	597,000	0	0	0	0
Coke	kg	7,200	0	0	155	1,116,000	0	0
Electric power	kWh	860	80	68,800	0	0	650	559,000
Blower	kWh	860	5	4,300	10	8,600		
Dust collector	kWh	860	6	5,160	20	17,200	6	5,160
Total				675,260		1,141,800		564,160
Heat efficiency %				57		33		68

Table 9 Energy used in each melting furnace and their heat efficiency (Electric power: indirectly input)

Kind of energy	Unit	Heating value (kcal)	Gas cupola		Coke cupola		Electric induction furnace	
			Energy consumption /ton	Energy (kcal/ton)	Energy consumption /ton	Energy (kcal/ton)	Energy consumption /ton	Energy (kcal/ton)
Natural gas	Nm^3	9,950	60	597,000	0	0	0	0
Coke	kg	7,200	0	0	155	1,116,000	0	0
Electric power	kWh	2,250	80	180,000	0	0	650	1,462,500
Blower	kWh	2,250	5	11,250	10	22,500		
Dust collector	kWh	2,250	6	13,500	20	45,000	6	13,500
Total				801,750		1,183,500		1,476,000
Heat efficiency %				48		32		26

6.3 Comparison of exhaust gas in melting

Exhaust gas of a conventional coke cupola and a natural gas cupola can be calculated from their fuel compositions and consumption.

Table 10 Composition and combustion product of foundry coke

Components (wt%)						Low-level heating value	Combustion product (m^3N/kg)			
C	H	O	S	H_2O	Ash	(kcal/kg)	CO_2	H_2O	N_2	SO_2
85.5	0.27	0.06	0.46	0.26	12.6	6,903	1.61	0.03	6.09	0

Table 11 Composition and combustion product of natural gas

Components (wt%)				Low-level heating value	Combustion product (m^3N/kg)			
CH_4	C_2H_6	C_3H_8	C_4H_{10}	(kcal/kg)	CO_2	H_2O	N_2	SO_2
88	6	4	2	9,698	1.17	2.17	8.55	-

From table 8, the consumption of natural gas in a natural gas cupola is $60m^3N$/ton, and the consumption of coke per 1 ton of molten metal in a coke cupola is about 150 kg/ton, and the amount of carbon dioxide generated are $1.17 \times 60 = 70.2\ m^3N$/ton for a natural gas cupola and $1.61 \times 150 = 241.5\ m^3N$/ton for a coke cupola; the amount of carbon dioxide generated in a natural gas cupola is no more than 29 per cent that generated in a coke cupola.

6.4 Advantages of a natural gas cupola

(1) Energy conservation

The heat efficiency of a natural gas cupola is higher than that of a coke cupola. It is somewhat lower than that of an electric induction furnace with electric power charged directly, but it is higher than that of other melting furnaces with energy charged indirectly.

(2) Improvement of environment

The amount of carbon dioxide in discharge gas of a natural gas cupola is 1/3 or less that of a coke cupola, greatly contributing to prevention of global warming. Sulphur oxides are not found in exhaust gas, ensuring cleanness, which is incomparable with several tens of ppm of a coke cupola.

(3) Recycling automobile scraps

Though in melting in an induction furnace, there are problems of worsening of working environment during melting, lowering of the quality of castings, shortening of life of refractories, etc. due to Zn galvanized steel plates of automobile scraps which are expected to increase in the future, the refining effect of a cupola makes it possible to recycle them. Harmful elements such as Pb, Sn, Al, etc. can be collected as oxides with a dust collector in the cupola.

7. Induction melting furnace

7.1 Features of induction melting furnace

In metallic material placed in magnetic field generated by the current in induction coil of the furnace, electromotive force is induced by the action of electromagnetic induction, and induced current flows to heat up the material by its Joule's heat. Compared to other types of melting furnace, induction furnace has the following features:

(1) Its heat efficiency is high because the material is directly heated by electromagnetic induction.

(2) No carbon dioxide is produced and little smoke and soot are emitted because cokes are not used as fuel.

(3) Metal loss by oxidation is little, thus little contamination of in metal because of heating without air.

(4) Temperature control is simple, uniform composition of metal product is attained by agitation effect and alloyed cast iron is easily produced.

(5) Induction melting is suitable for high temperature melting because of its energy concentration, and installing space is reduced as compared with other types of melting furnace.

Induction furnace is classified into the following types according to its structure and frequency applied:

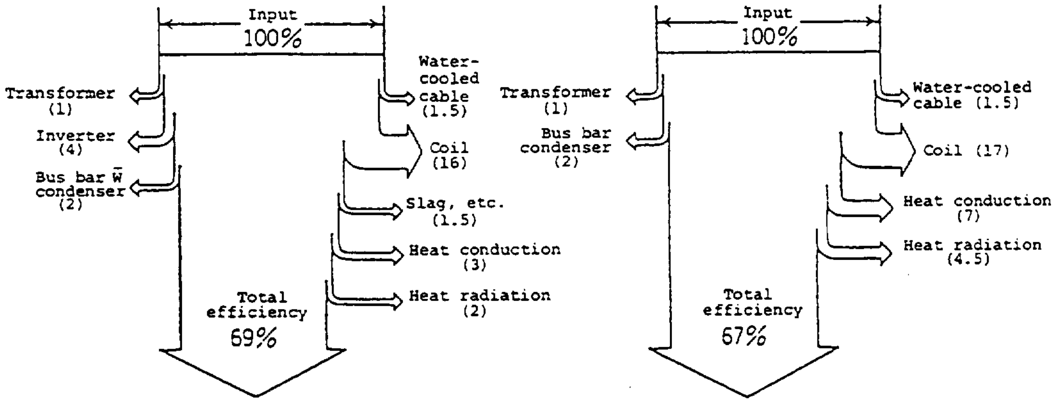
- Induction furnace
  - Crucible type
  - Channel type
- Crucible type / Channel type
  - Low-frequency type, Commercial frequency (50 Hz, 60 Hz)
  - High-frequency type (over 500 Hz)

7.2 Heat balance of induction furnace

7.2.1 Total efficiency of induction furnace

Efficiency of induction furnace is expressed as a total, deducting electrical and heat transfer losses. Heat balance diagram of crucible type induction furnace is shown in Fig.24.

Electrical losses consist in transformer, frequency converter, condensor, wiring, cable, coil, etc. Loss in coil is essential factor, on which the furnace capacity depends.



(a) Distribution of losses in high-frequency of furnace. Heat loss [%] is given in ( ).

(b) Distribution of loss in low-frequency furnace. Heat loss [%] is given in ( ).

Fig.24 Heat balance diagram of crucible type induction furnace.

Heat losses in induction furnace consist of conduction loss of heat escaping from furnace wall to coil side, radiation loss of heat released from melt surface, absorption loss in ring hood, slag melting loss, etc. Shown in Table 11 is an example of heat balance table of low-frequency and high-frequency induction furnaces.

Heat efficiency of high-frequency furnace (60 - 78 per cent) is slightly larger than that of low-frequency furnace (58 - 71 per cent). Low-frequency furnace is larger in heat loss, while high-frequency furnace is larger in electrical loss.

This is explicable from the fact that low-frequency furnace has lower power density at melting and larger heat loss due to long melting time, while high-frequency furnace has higher power density, heat loss is small due to short melting time and primary electrical loss is large due to frequency conversion.

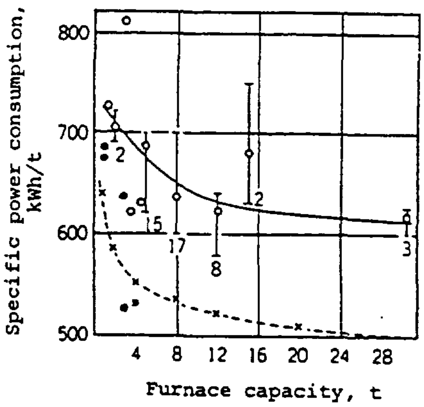
Table 12 Heat balance of induction furnaces at continuous operation

Type of furnace		Low-frequency furnace				High-frequency furnace			
		Channel type		Crucible type					
Rating	[kW]	300	1600	300	1600	300	1600	300	1600
	[t]	5	30	1	8	0.5	2	0.1	0.5
	[Hz]	50	50	50	50	500	500	3000	3000
Current density	[kW/kg]	0.06	0.05	0.3	0.2	0.6	0.8	3.0	3.2
Heat efficiency	[%]	67.2	79.0	58.1	71.0	60.4	73.2	61.0	66.4
Heat loss	[%]	23.6	13.0	7.5	5.7	4.5	2.1	2.2	1.3
Electrical loss	[%]	3.0	2.8	28.2	18.0	25.2	15.4	21.1	18.5
Wiring loss	[%]	3.3	2.8	3.3	2.0	3.2	2.7	2.8	2.6
Secondary power loss	[%]	1.3	0.9	1.3	1.0	2.2	2.1	2.8	2.9
Primary power loss	[%]	1.6	1.5	1.6	1.5	4.5	4.5	7.1	8.3
Melting power rate	[kWh/t]	-	-	655	534	628	520	622	572
Heating power rate	[kWh/t]	36	30	41	34	40	33	38	36

Remark: Melting power rate is given up to 1500℃ and heating power rate is shown by 100°C.

7.2.2 Power consumption rate

Fig.25 shows the relationship between furnace capacity and the power consumption rate, i.e. electric energy required for melting each ton of metal. Power consumption rate is lowered as the furnace capacity is increased approximately up to 12 to 15 tons, thereafter consumption rate remains unchanged at about 610 kWh/t. Power consumption rate of small-sized furnace about 1 to 3 tons exceeds 700 kWh/t. Dotted line with "×" marks in the figure



Remarks: Broken line with marks "x" shows standard rated values. Marked with • are given for high-frequency furnace, and marked with "*" are given for melting in two furnaces.

Fig.25 Furnace capacity and specific power consumption.

shows the power consumption rate at standard rating of the furnace with remaining 1/2 melt in the furnace, which is calculated about 100 kWh/t lower than actual consumption. This rated value does not include the electric energy required for holding molten metal, slag removing, tapping and other related operations. This difference in theoretical and practical values indicate the possibility for decreasing the power consumption rate.

7.3 Energy saving measures for induction furnaces

7.3.1 Improved heat efficiency by improvement of furnace

Energy efficiency at the power source side, such as frequency convertion efficiency, power-factor improving capacitor, etc., including proper coil design, cannot be adjusted by the user. On introducing the induction furnace, specific features of the furnace must be understood fully to make the proper decision about the kind of material, the size and shape of charging materials to be melted, melting amount, connection with pouring line and layout of the melting shop.

(1) Equipment layout

Induction furnace equipment should be melted with minimum distance between each equipment to reduce wiring losses. To reduce the wiring losses remarkably, it is essential to shorten the distance between furnace body and power-factor improving capacitor as very large current flows between them.

(2) Frequency

(a) Skin effect: Induction current flows concentratedly on the surface of material to be melted. This concentration of current becomes more evident as the frequency becomes higher, resulting in better heating efficiency.

Diameter or thickness of material to be melted in the furnace may be decreased accordingly as the frequency becomes higher. When cast iron is melted in high-frequency induction furnace, there is practically no limitation in its size, but in low-frequency furnace when starting with cold metal, melting has to be started only by the use of a starting block. Continuous melting is to be performed with residual molten metal.

(b) Effect of agitation: As molten metal is agitated by opposing currents flowing in the induction coil, molten metal is agitated to raise its surface in the center. The surface of molten metal rises as frequency becomes lower, i.e. agitation of molten metal is stronger in low-frequency furnace than in high-frequency furnace. This effect of agitation makes it possible to ensure uniform temperature of molten metal and its uniform quality as well as to promote entrapment of material charged and fusion of chemical composition adjusting agents, specially carbon addition. On the other hand, excessive agitation may cause such troubles as oxidative wearing of molten metal and fusing out of refractories or danger of spattering of molten metal. In this respect, as compared with low-frequency furnace, high-frequency furnace can be charged with stronger electric power at the same agitation degree, which will speed up the melting and improve the furnace heat efficiency because high-frequency furnace can be operated with power density about three times larger than that of low-frequency furnace.

7.3.2 Improvement of heat efficiency in operation

(1) Improvement of heat efficiency

a) Tapping temperature should be as low as possible.

Heat capacity of molten metal increases with increasing the tapping temperature, and furnace heat loss is fully proportional to melting temperature. Heat capacity of gray iron increases about 20 kWh/t as its temperature rises per 100°C. Heat conduction loss (Q_C) and radiation loss (Q_R) are calculated as follows:

$$Q_C = \frac{T-t}{R} \cdot 10^{-3} \cdots\cdots (1)$$

Q_C : Conduction loss (kW)

t : Cooling water temperature (°K)

T : Molten metal temperature (°K)

R : Heat resistance of furnace wall (kW/°K)

$$Q_R = 5.67 \cdot 10^{-3} \cdot A \cdot \varepsilon \cdot (T/100)^4 \cdots (2)$$

Q_R : Radiation loss (kW)

ε : Emissivity

A : Surface area of molten metal (m^2)

From the above-mentioned equations it follows that conduction loss and radiation loss of high-frequency furnace with 1t, 500 Hz and 900 kW at tapping temperature of 1500°C come to 50 kW and 35 kW respectively, and these losses can be reduced approximately by 10 kW each at tapping temperature of 1400°C.

To keep the tapping temperature lower, it is necessary to practice carefully thought-out measures, for example inoculation, laddle travelling distance, preheating and covering of laddle, etc.

b) **Furnace cover should be closed as far as possible.**

As calculated by the above-mentioned equation (2), heat radiation loss from molten metal surface is proportioned to the forth power of temperature. This heat loss at temperature of about 1500°C comes to

60 - 70 kW/m^2, which is the maximum loss in melting. In practical furnace operation, especially in the case of a small-sized furnace, the furnace cover sometimes remains open carelessly. It is important to train personnel and make the necessary preparations to charge materials and adjusting agents regulator as quick as possible.

As the effect of furnace cover against radiation loss reduced by half, even if a small opening exists in the covering, any erosion of refractory by expansion or dropping at the top of crucible and/or furnace cover has to be repaired deligently.

c) Molten metal should be held at low temperature and in short time

Molten metal should be held, when required, at low temperature, or the power supply should be turned off. Rated power should be turned on to heat up again. Chemical analysis of molten, preliminary furnace test and temperature measurement should be performed quickly. Preparatory operations should certainly be performed so that there is no unmatching with mold assembly or waiting for crane.

d) Dust collecting hood

The degree and time of dust collecting should be controlled according to furnace running conditions.

e) Cleaning of sand, rust and other dirts

Sand or rust (Fe_2O_3, FeO) adhered to cast iron or steel scrap may react with furnace refractory to form slags. If slags are formed, about 1 per cent in melting of 3 tons iron, power loss at 1500°C is about 10 kWh/t.

(2) Maximum power supply

It is correct to increase power input for improvement of heat efficiency of the furnace. Maximum capacity of the furnace can be attained and power consumption rate can be reduced when operating the furnace with constant rated power.

a) Raw material at the start of melting

Raw material should be charged as dense as possible. It is better to charge return scrap having low melting point for quick melting to improve power load factor.

b) Additional material charging

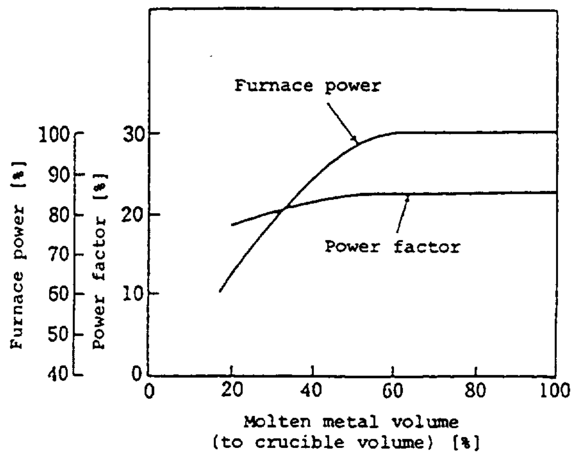
Additional cold material should be successively charged into the furnace when the first charge starts melting. Each charge should be about 10 per cent of crucible volume so as to close the furnace cover.

c) Machining chips

Machining chips or other fine materials having a small bulk specific gravity cannot be heated effectively. They must be charged into molten metal built up previously in the furnace, making use of the agitation effect of molten metal. As machining chips may be stuck on furnace wall by electromagnetic force, the power supply should be turned off at intervals for of the chips to fall down.

d) Melting with residual molten metal

In case of low-frequency furnace, melting with residual molten metal is indispensable to improve the power load factor of low-frequency furnace. Fig.26 shows the relationship between the percent of molten metal volume and furnace load characteristics. As may be seen from the figure, rated power is loaded for not less than 50 per cent of residual molten metal. Residual molten metal is not especially required for high-frequency furnace, but residual molten metal about 5 - 10 per cent may improve the power load factor and increase the melting capacity as compared with melting from completely cold material.



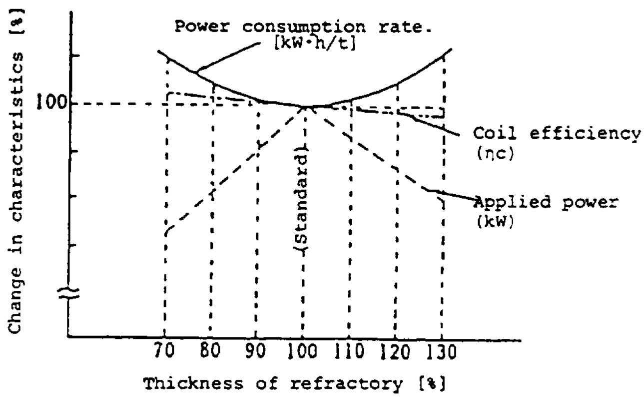


Fig.26 Load characteristics of low-frequency furnace.

Fig.27 Furnace characteristics versus refractory thickness.

e) Keeping up the furnace inner diameter

Rated power is supplied to the furnace only when thickness of furnace refractory remains normal. Fig.27 shows the furnace characteristics versus refractory thickness. Furnace power may be lowered when its inner diameter changes due to erosion of furnace wall or slag attached to the wall. Furnace wall damaged by erosion should be repaired to maintain the standard diameter in respect to thermal efficiency of the furnace. Before charging the material it is necessary to remove sand, rust and other foreign matters causing slag formation.

7.3.3 Preheating of material

The quantity of heat required for cast iron melting process upto its melting point (about 1150°C) accounts for 65 per cent of the total heat consumed for heating cold material of room temperature (20°C) to tapping temperature (1500°C). Induction furnace consumes 87 per cent of the total power consumption required for melt down. Remarkable power saving may be realized if the raw material is preheated upto 500 - 600°C by any method more effective than induction heating.

Preheating of material has the following advantages other than the above-mentioned:

i) avoidance of steam exprosion caused by condensation of moisture on the surface of cold charge material;

ii) possibility of energy cost saving;

iii) improvement of melting capacity by reducing the melting time in induction furnace.

(1) Preheating furnace type

There are many types of preheating furnace; charging bucket of induction furnace is used as preheater, at the top or bottom of which combustion chamber is provided and generated hot air is passed through the charged material; material in preheating chamber is heated up by circulating hot air fed out of combustion chamber, then material heated is charged into induction furnace by means of shooter; or material is heated directly and continuously by burner on vibrating conveyor or in kiln, etc.

(2) Example of preheating furnace

This is an example of research and development work performed for high-speed induction melting furnace system with effective use of preheating equipment.

This melting furnace is of high-frequency induction type with capacity of 600 kW-1t. Specifications of its preheating furnace is given hereafter and its configuration is shown in Fig.26.

Materials to be preheated: Cast iron (20%), return iron scrap (40%), steel scrap (40%)

Weight of preheated material: 1t/charge (at bulk specific gravity 2.0)

Volume of preheating chamber: 0.6 m^3, 45°C inclined rectangular type

Preheating temperature: 450 - 500°C (Max 600°C)

Preheating time: 30 - 40 minutes

Preheating system: Hot air circulating system

Hot air temperature: 600°C (PID control at preheating chamber inlet)

Heat source: Town gas (Rated capacity of burner: 40×10^4 kcal/h)

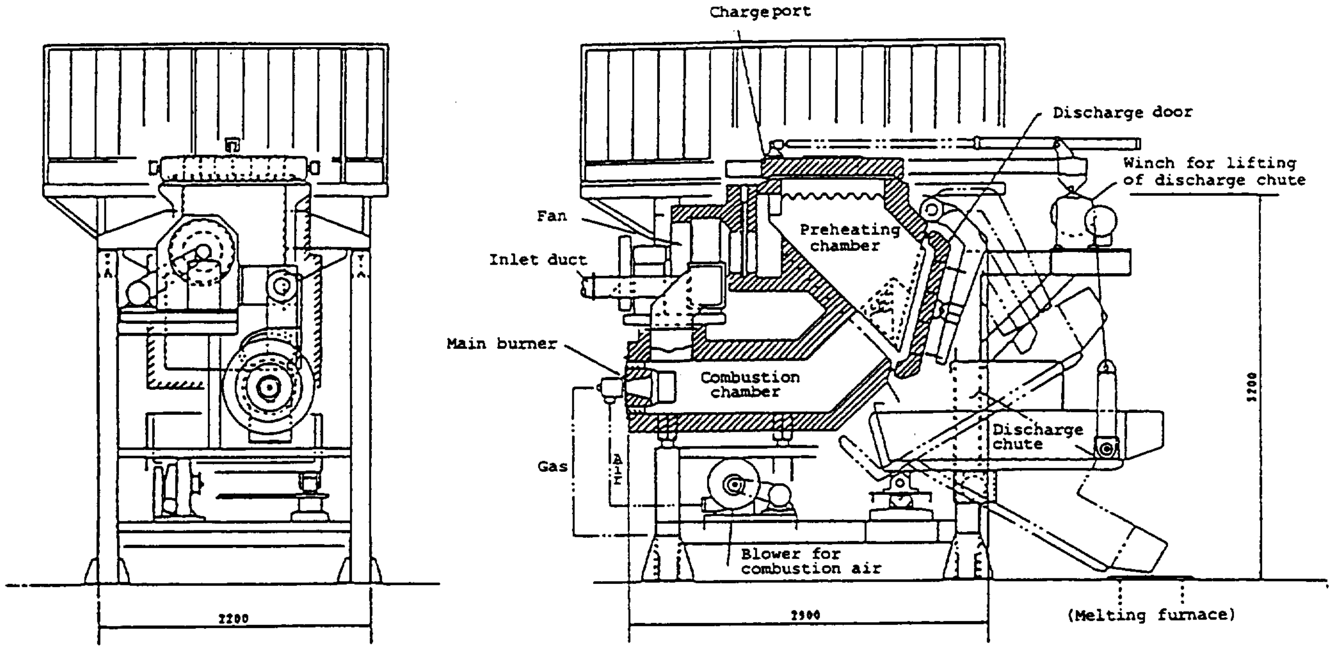


Fig.28 Details of preheating furnace (Preheating by hot air circulation and material charging by chute)

Heat balance table of this preheating furnace is given in Table 13.

Absorption heat of material at first charge is low due to heat accumulation in cold furnace body, but absorbtion heat from the second and following charges reaches 60 per cent, assuring high heat efficiency.

Table 13 Heat calculation of preheating furnace.

		1st charge		2nd charge		3rd charge	
		Q'ty of heat	%	Q'ty of heat	&	Q'ty of heat	%
Input heat	Gas combustion heat	119,500	100	97,600	100	92,700	100
Output heat	Absorption heat of material	56,700	47.2	56,500	57.9	57,300	61.8
	Loss in exhausts	9,800	8.2	11,900	12.2	10,300	11.1
	Heat radiation of furnace body	300	0.3	2,200	2.3	3,500	3.8
	Heat accumulation of furnace body, etc.	52,700	44.1	27,000	27.6	21,600	23.3

Figs.29 and 30 show the temperature-rising characteristics of charged material. Temperature of hot air at first charge rises slowly due to heat accumulation in furnace body, but temperature of both hot air and material at second, third and following charges rises quickly.

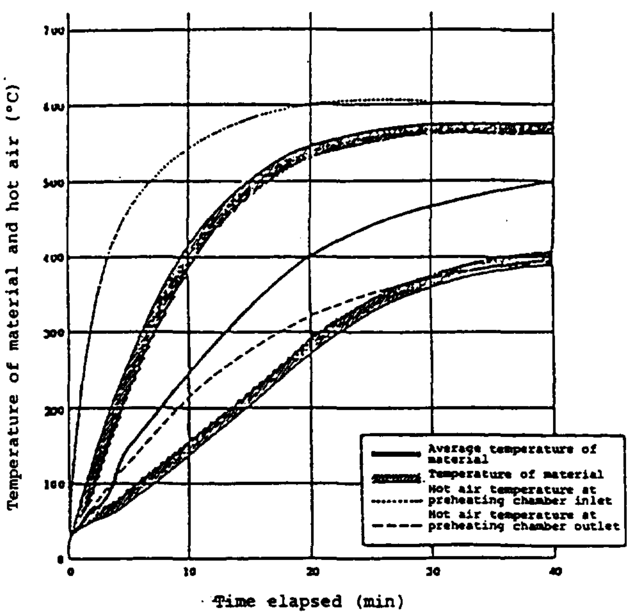


Fig.29 Temperature rising characteristics at first charge.

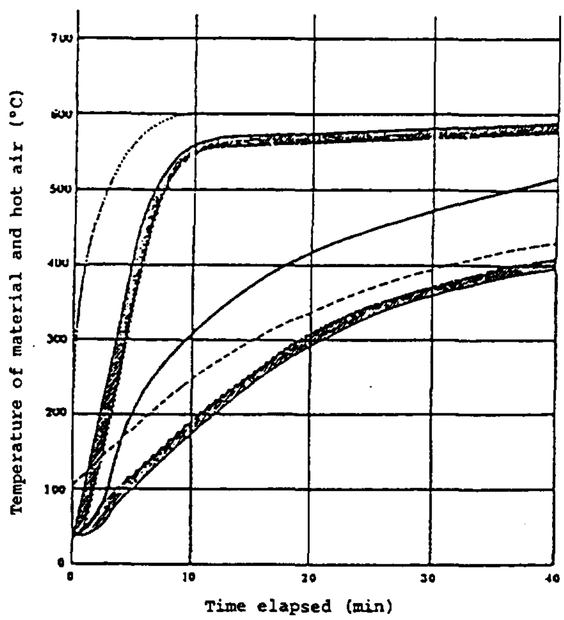


Fig.30 Temperature rising characteristics at 2nd & following charges.

(3) Effects of preheating

In Table 14 the melting characteristics of preheated material compared to non-preheated one are given. Effects of preheating are as follows:

i) Power consumption rate is reduced by 25.4 per cent, from 626 kWh/t to 467 kWh/t.

ii) Total unit consumption of energy including gas consumption is saved by 6.3 per cent, from 538.4×10^3 kcal/t to 504.6×10^3 kcal/t.

iii) Melting capacity is improved by 27 per cent, from 0.81 t/h to 1.03 t/h, namely daily output of melt is increased from 7 tons to 9 tons.

Preheating may cause such demerits as the increase of metal loss by oxidation in the preheating process, detrimental effect on the product quality, etc. As may be seen from Fig.31, oxidation of carbon steel material is slightly under the temperature of 600°C and proceeds rapidly over this temperature. This preheating equipment is constructed of hot air circulating type with separate combustion chamber from preheating chamber so that hot air over 600°C does not directly touch the material to be preheated to eliminate the possibility of oxidation during its preheating.

Table 14 Comparative melting characteristics of induction furnaces in reference to preheating.

High-frequency induction furnace			without preheating equip't 600 kW-1t	with preheating equip't 600 kW-1t
Preheating temperature			Room temperature	Average 500°C
First melting	Gas consumption	[m³]	-	14.5
	Electric power consumption rate	[kWh/t]	710	590
	Melting time	[min]	84	76
	Melting times		1	1
	Tapped melt	[t]	1	1
Continuous melting	Gas consumption	[m³]	-	9.8
	Electric power consumption rate	[kWh/t]	600	440
	Melting time	[min]	63	46
	Melting times		6	8
	Tapped melt	[t]	6	8
Holding	Holding power	[kW]	80	80
	Holding time	[min]	8	8
	Holding times		7	9
Operating time		[h]	8.6	8.6
Total power consumption		[kWh]	4,385	4,206
Total gas consumption		[m³]	-	92.7
Total daily melt tapped		[t/day]	7	9
Melting capacity		[t/h]	0.81	1.05
Electric power consumption rate		[kWh/t]	626	467
Heat consumption rate of electricity		[kcal/t]	538.4×10^3	401.6×10^3
Gas consumption rate		[m³/t]	-	10.3
Heat consumption rate of gas		[kcal/t]	-	103×10^3
Total heat consumption rate		[kcal/t]	538.4×10^3	504.6×10^3

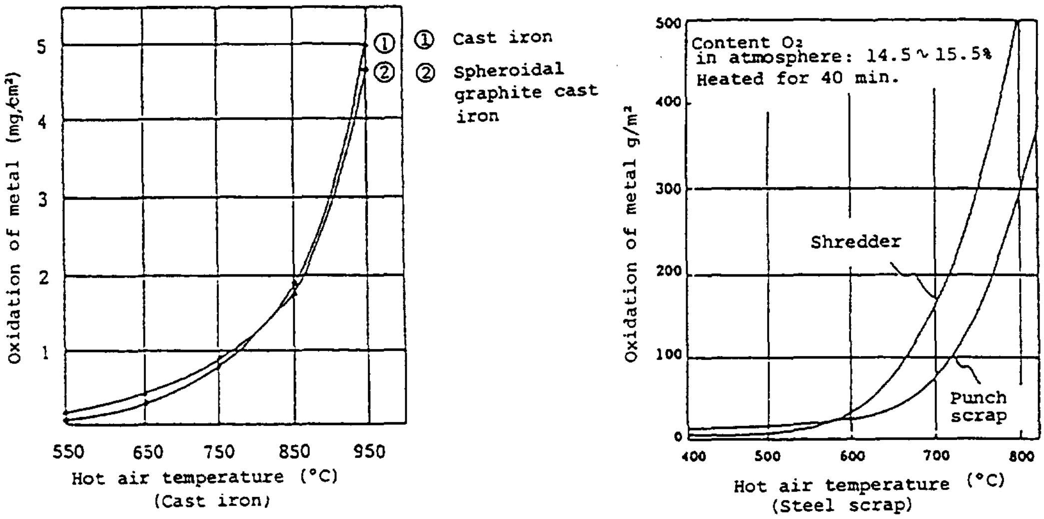


Fig.31 Oxidation of material in hot air

8. Arc furnace melting

Arc furnace essentially has been designed and has been developed as a steel melting furnace and its recent technological innovation is remarkable. But in Japan there is a trend to indicate technological problems of melting of cast iron by arc furnace, so arc furnace accounts for only 3 - 5 per cent of cast iron melting furnaces, including the use as dual melting combined with cupola and the likes.

8.1 Melting energy

In case of arc furnace the melting heat efficiency in the process from ordinary temperature upto melt-down is high compared with other melting furnaces, but the heat efficiency in superheating process after melt-down is lower than half of low frequency induction furnace. (Fig. 32)

The total energy for iron melting is consumed for preheating (20°C ~ 1200°C), melting (1200°C), and superheating (1200°C ~ 1550°C), which makes up 57 per cent, 19 per cent and 24 per cent respectively, and this shows that energy consumption until melt-down amounts to 76 per cent of the total energy. (Fig.33)

In consideration of the above-mentioned, cast iron mass production foundry have increasingly adopted dual melting process designed to combine effective furnaces specialized separately for metal melting and for holding and adjusting chemicals.

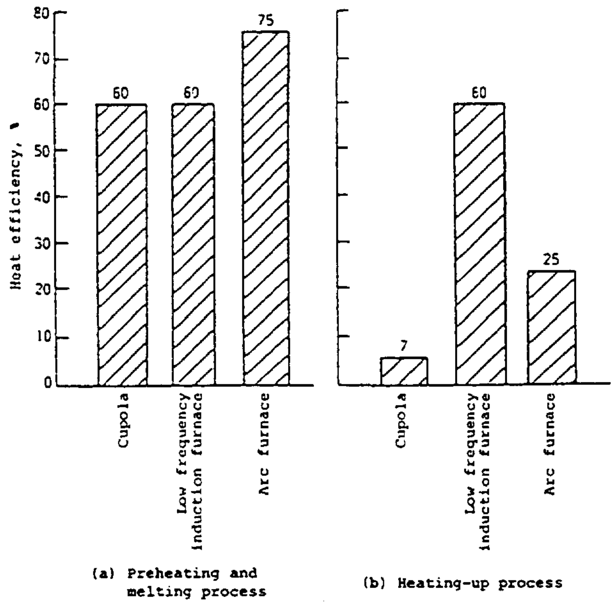


Fig.32 **Heat efficiency in iron melting**

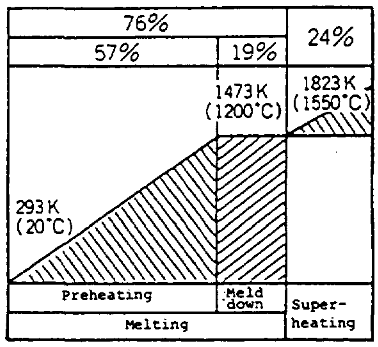


Fig.33 **Example of quantity of heat in iron melting and superheating**

8.2 Energy saving measures for arc melting furnace

(1) Decreasing of heat input

(a) Substitution of heat input

In arc melting furnace, in order to shorten the melting time to improve productivity and power consumption rate, sometimes oxygen is blown in during melting and sometimes fuel oil, kerosene or the likes with oxygen to be burnt directly in the furnace.

(b) Preheating of charged material

Another effective method is preheating charged material by sensible heat of exhaust gas or other kinds of fuels, which enables a reduction in heat input by sensible heat of materials and decreases the power consumption rate. Material in closed charging basket may be preheated from its upper and lower sides by means of burner, or preheated in the preheating reservoir with bypass provided directly in the duct between dust collector and arc furnace by using exhaust gas. Utilization of exhaust heat allows electric power savings of 20 ~ 50 kWh/t.

(c) Lowering of tapping temperature

By preheating the ladles sufficiently, by covering the ladles to prevent temperature drop by radiation, by shortening the processing time, including spheroidizing, inoculation, etc., and by decreasing the delivery distance, the tapping temperature shall be as low as possible.

(2) Reduction of heat loss

(a) Improvement of furnace performance

The larger the furnace capacity, the lower the lower consumption. Fig. 34 shows the relationship between capacity and power consumption rate of the steelmaking arc furnace.

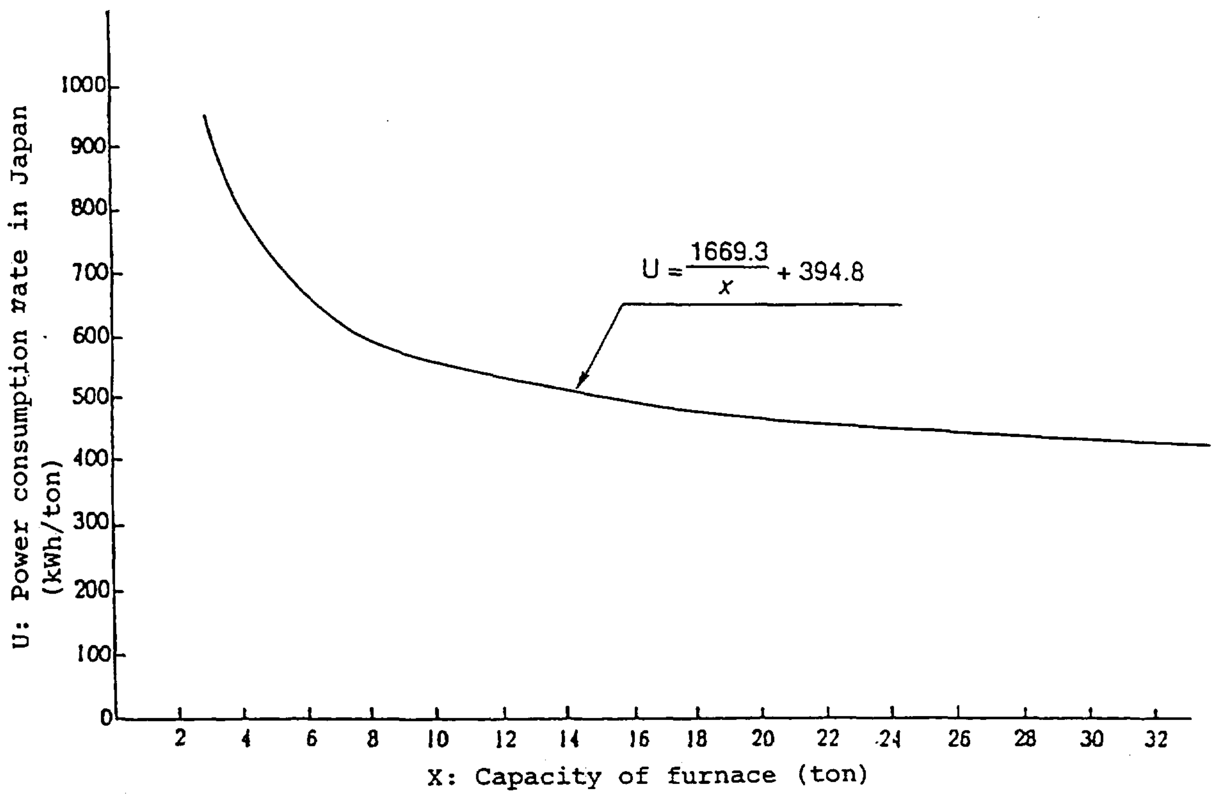


Fig.34 Capacity and power consumption rate of steel making arc furnace.

There are a lot of new designs for improvement of arc furnace performance, so adoption or improvement of arc furnace requires adequate study about them. For example,

i) Ultra high power (UHP) operation for rapid melting

Low voltage and large current can make stable and thick short arc, which allows rapid melting with less errosion of refactories. Theoretically, efficiency in such operation may be 2.3 times as large as conventional regular power(RP) operation.

ii) Automatic electrode control

This system enables the fluctuation of arc current to be kept as law as possible to keep power constant.

iii) Transformer secondary cable

The water-cooled cable is used as a flexible connecting cable between transformer and electrode in order to reduce resistance.

iv) Decreasing furnace openings

Prevention from heat radiation requires decreasing the furnace openings as far as possible. In general, melt is discharged through spouts, but in some cases tapping holes are located at the center of the hearth to shorten the tapping time and reduce the heat loss. In addition, there is an economizer, consisting of a water-cooled ring located on the electrode hole in the furnace cover, which reduces the flame blowout from electrode holes and decreases oxidation loss of electrode by cooling effect.

v) Water cooling of furnace wall

In many cases water-cooled box is arranged on high temperature spots of furnace wall to shorten the repairing time and decrease the power consumption rate.

(2) Improvement of operating methods

(a) Quick charging of raw material

In order to reduce the heat radiation from furnace, materials should be charged one time for the whole amount; but in practice materials are charged additionally 0 - 2 times. After starting, when melting becomes available, additional amount of materials must be charged immediately .

To protect the hearth and make melting easy, heavy-, medium- and light-weight materials are charged in order from the bottom. Attention must be given to the charging position so as not to destroy electrodes through heavy-weight material falling down.

(b) Appropriate power input

Since power and time consumed during the melting period will account for the greater part of those required during the whole process, rapid melting needs additional energy supply, such as electric power and others. In the above-mentioned UHP operation, auxiliary burning by means of side burner and the likes are well-known methods. Just after starting to apply the electric current, the current fluctuates violently due to contact between materials and electrode, creating reactance in the circuit designed; but when metal starts melting the current is stabilized, the reactance is then eliminated and the power can be supplied efficiently.

(c) Cut down of the idling time

Time management, including reduction of the analysis time, elimination of the waiting time for the crane, etc., must be made positively. Decreasing the furnace repairing time is one of the important energy saving measures.

(d) Improvement of dust collecting efficiency

In many electric furnace shops the buildings are provided with a dust collecting system for environmental protection inside and outside the foundry. A new concept collects dust directly from the arc furnace or encloses the furnace entirely with panels so as to improve dust collecting efficiency. Utilization of exhaust gas in material preheating process allows the recovery of exhaust heat and makes exhaust gas temperature lower, which serves to simplify the dust collecting equipment.

(3) Improvement of product yield

As mentioned before, improvement of product yield has more important effect on the energy consumption rate of the product rather than on the power consumption rate for melting. Moreover, it is important to reduce the weight of metal to be melted by lessening the defective casting ratio and decreasing the amount of remaining melt in the ladle and furnace.