

2004 Prize of the Chairman of ECCJ

Energy Conservation Activities for Factory by Recovering and Reusing Hot Water Waste Heat of Cogeneration System

TOTO Ltd. Nakatsu 2nd Factory
Ceramic Production Management Section
Engineering Team

Keywords: Waste heat recovery and usage

Outline of Theme

As the concern about the global warming is spreading in recent years, companies or organizations are requested to reduce the use of energy, because approximately 90% of CO₂ emitted on the earth is generated by energy consumption. Therefore, it is an urgent issue to rationalize the use of energy. Responding to these requirements, we improved heat efficiency by reusing the waste heat of our cogeneration system as the heat source of the air conditioning equipment. We also built a system with which each division using energy could know and manage the daily energy usage (visible management), so that everybody in the factory can work on the energy conservation activities and achieve a big result.

Main activities included the followings.

- [1] To increase the amount of waste heat recovered from the cogeneration equipment (37% -> 86%).
- [2] To build energy conservation management network (energy conservation activities based on the visible management).
- [3] To implement energy conservation measures (32 measures).
- [4] To enhance energy conservation awareness by announcing the energy conservation activities on the bulletin board.

Implementation Period of the said Example

April 2003 – March 2004

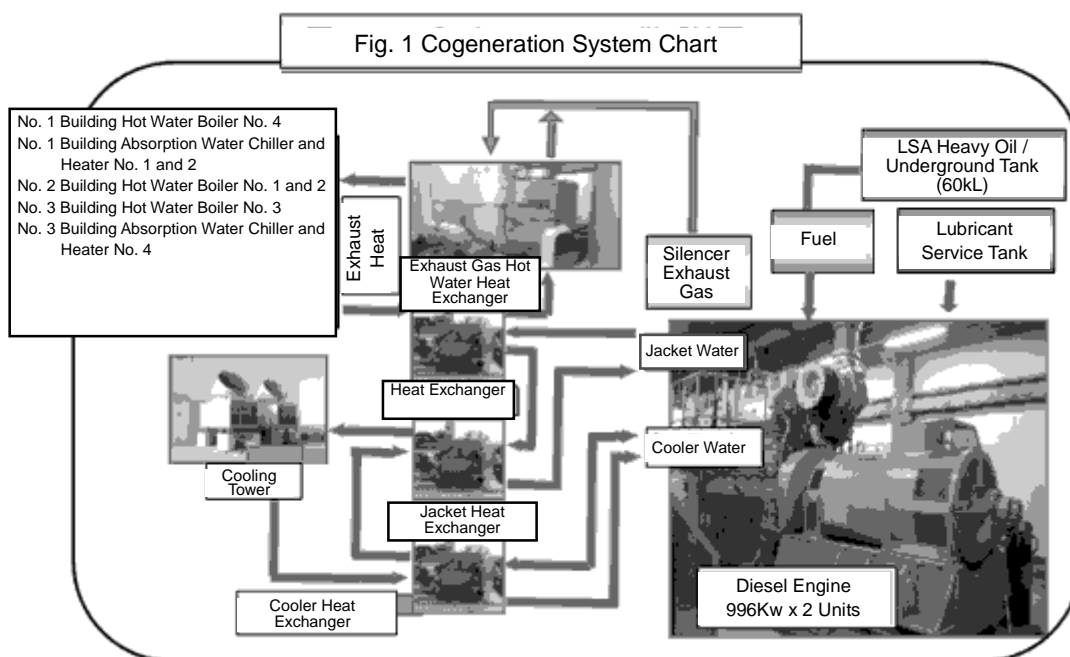
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|----------------------------------|--------------------------|----------------|
| ● Project Planning Period | April 2003 – May 2003 | Total 2 months |
| ● Measures Implementation Period | June 2003 – January 2004 | Total 8 months |

- Measures Effect Confirmation Period February 2004 – March 2004 Total 2 months

Outline of the Business Establishment

- Items Produced Ceramic products
- No. of Employees 350 (As of April 1, 2004)
- Annual Energy Consumption (Actual results for fiscal year 2003)
 - Fuel (crude oil equivalent) 3,621 kL/year
(Breakdown: LSA heavy oil, 2,126 kL/year, LPG 1,206 kL/year)
 - Electricity 10.47 million KWh/year

Outline of Target Facilities



1. Reasons for Theme Selection

This factory had been actively engaged in the energy conservation activities through the “Special Sub Committee on Factory Energy Measures” organized within the Factory Global Environment Preservation Committee. However, the specific energy consumption became worse due to introduction of the cogeneration facilities, factory construction and the decrease of production volume. Meanwhile, we aimed to improve the specific energy consumption with the manufacturing division to promote the “improvement of the specific

energy consumption by 1% compared with the level of the previous year” provided by the Energy Conservation Act.

2. Understanding and Analysis of Current Situation

(1) Understanding of Current Situation

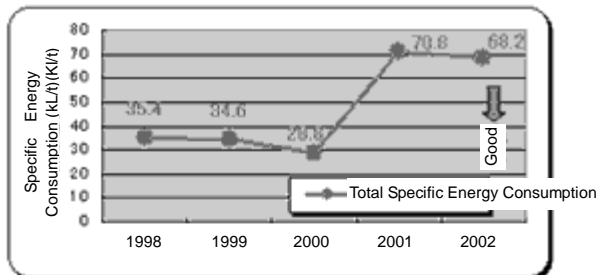


Fig. 2-1 Transition of Total Specific Energy Consumption

This factory uses electricity, LSA heavy oil and LPG as fuel. The specific energy consumption of the past 5 year shows that it worsened in FY2001 due to the introduction of the cogeneration system and the construction of No. 3 building in that year. The specific energy consumption improved only 1% in FY2002. The total specific energy consumption of the factory was the worst in the factories of the company. (Fig. 2-1)

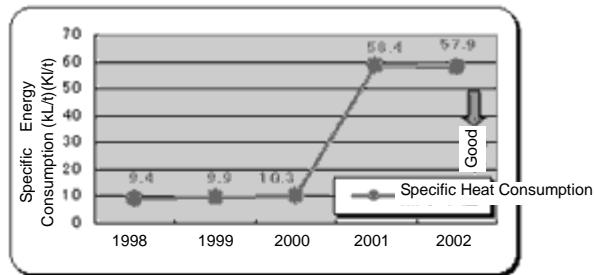


Fig. 2-2 Transition of Specific Heat Consumption

The specific heat energy consumption improved 0.5% in FY2002. The reason that the specific energy consumption does not improve seems to be the heat energy. (Fig. 2-2)

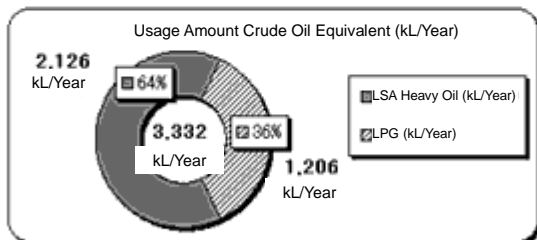


Fig. 2-3 Usage Amount Ratio by Kind of Energy

In the total energy usage, LPG accounts for 36%.

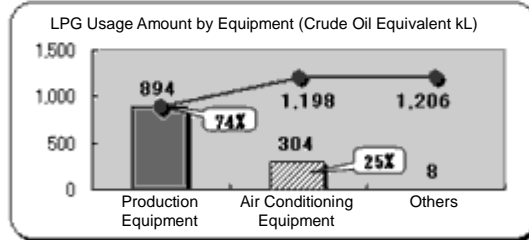


Fig. 2-4 LPG Usage Amount Ratio by Equipment (Crude Oil Equivalent)

In the total LPG used by the equipment, the production equipment accounts for 74% and the air conditioning equipment accounts for 25%. The Manufacturing Division is responsible for the energy conservation of the production equipment and the Engineering Division is responsible for the energy conservation of the air conditioning equipment. (Fig. 2-4)

(2) Analysis of Current Situation

1)

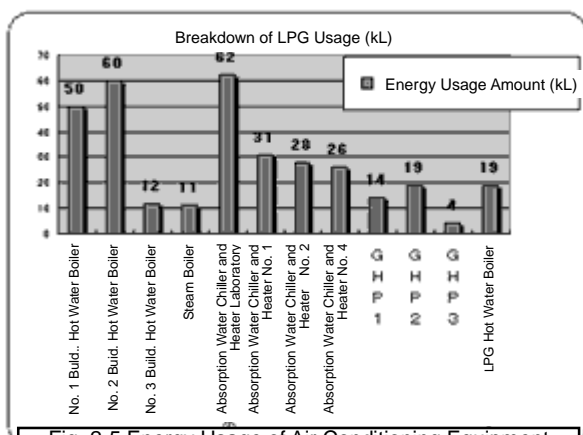


Fig. 2-5 Energy Usage of Air Conditioning Equipment (Crude Oil Equivalent)

It is important to do energy conservation for the hot water boilers and the absorption water chiller and heater which use a lot of energy.

(Fig. 2-5)

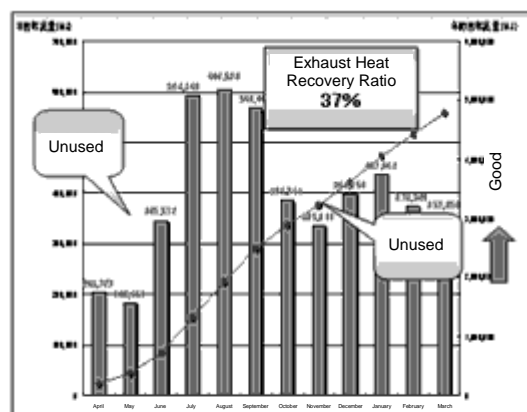


Fig. 2-6 Exhaust Heat Recovery Ratio in Cogeneration System

The exhaust heat recovery ratio of the cogeneration system is 37%. It must be efficiently used.

(Fig. 2-6)

2) The measures requested by the Factory Energy Measures Special Sub Committee are as follows.

- [1] To visualize the management after the energy conservation activities.
- [2] To let everybody know the price of electricity, LPG, water, etc. by posting their unit price to encourage them to do the energy conservation activities.
- [3] To appoint appropriate people to propose and study energy conservation measures in each division.

3. Progress of Activities

(1) Implementation Structure

The Sub Committee on Energy Measures in Factory is established as a subordinate body of the Factory Global Environment Preservation Committee to organize entire energy conservation activities including examination and implementation of energy use, energy conservation measures, etc. Furthermore, a committee member for management is appointed in each section to conduct concrete energy/resource conservation activities.

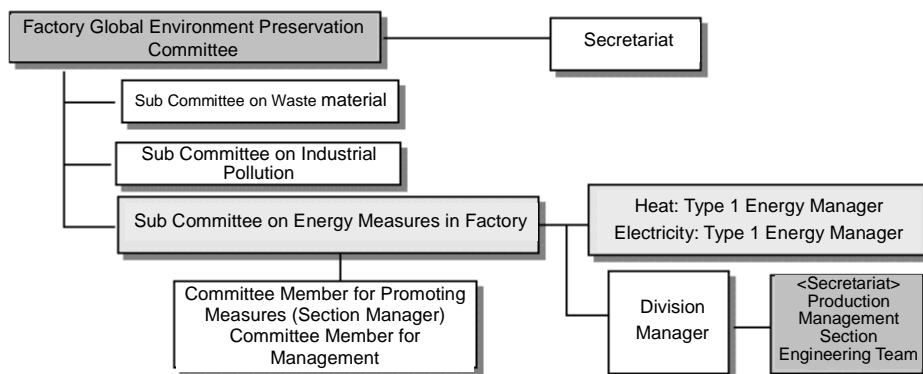


Fig. 3-1 Implementation Structure

(2) Target Settings and Problems

We made a heat energy map, system chart and heat balance chart to understand the current situation, then set the targets as shown in Table 3-1 to reduce the use of electricity and LPG and promote the energy conservation activities.

Table 3-1 Targets and Problems

No	Objectives	Targets	Problems
1	To improve the specific energy consumption by effectively recovering and using the waste heat.	To improve the specific energy consumption by 20% or more compared with the FY2002 level.	To improve the heat recovery amount of the cogeneration system (by making a management manual setting table and heat energy map).
2	To build an energy conservation management network.	To conduct energy conservation activities by visualizing the management.	To build a "visible energy management" system (TOTO's original system).
3	To cut the cost by implementing energy conservation measures.	To cut 9.5 million yen/year.	To implement energy conservation measures by the Sub Committee on Energy Measures.
4	To enhance energy conservation awareness.	To encourage by announcing the energy conservation activities on the bulletin board.	To announce the energy conservation activities and energy unit price on the bulletin board.

Table 3-2 shows the energy conservation activities by the Sub Committee on Energy Measures in Factory

FY2003 Energy Conservation Activity Plan (32 Activities)						2003年度 専ら工場(工場部門)											
No	Classification	Measures	Place	Details of Improvement	Estimated Effect	Plan						Implementation					
						First Half Period			Second Half Period			First Half Period			Second Half Period		
						4	5	6	7	8	9	10	11	12	1	2	3
1	工務	1. 2階温水ボイラーにコージェネ温水利用	1. 2階	コージェネ温水回収利用LPG削減を図る	20kWh/年												
2	工務	1. 2階温水ボイラーにコージェネ温水利用	1. 2階	コージェネ温水回収利用LPG削減を図る	102kWh/年 203kWh/年												
3	工務	コンプレッサー電力量の削減	全般	1・2・3階エアータンクをグループ化する	492kWh/年												
31	機電	アルミ子機用コンプレッサーモーターエアータンクに切替	1. 2階	20kWhコンプレッサー停止による電力削減を図る	42,000kWh/年												
32	発給	外灯LED化	※	※外灯LED化による電力削減を図る	1,200kWh/年												

Table 3-2 Energy Conservation Activity Yearly Plan

4. Details of Measures

(1) Improvement of Specific Energy Consumption by Effective Use of the Recovered Waste Heat

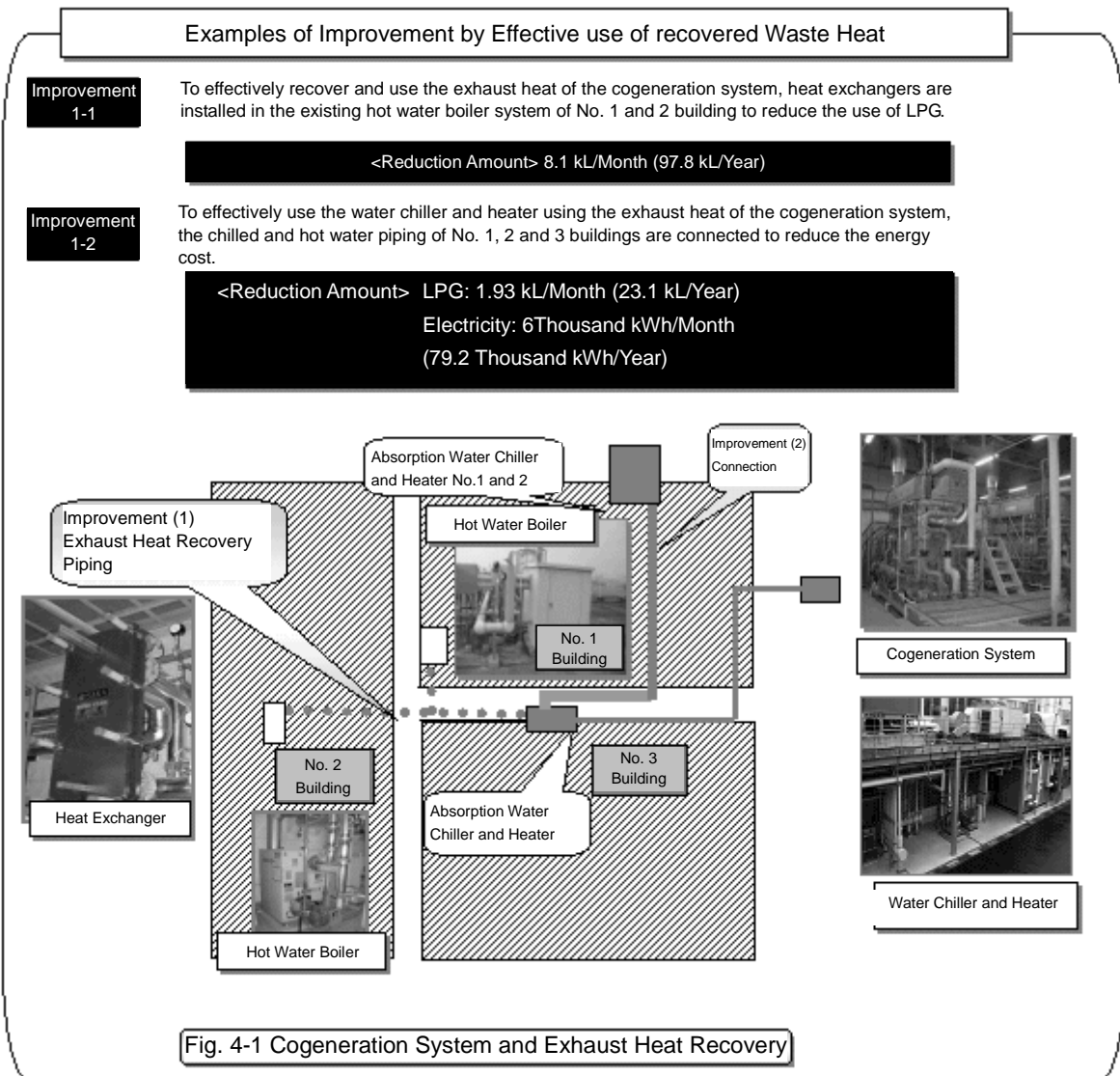
Improvement 1-1

To effectively use the waste heat of the cogeneration system as heat source of the supply side, the exhaust heat piping is extended to the existing hot water boiler system of No.1 and 2 buildings and heat exchangers are installed to stop the existing 3 hot water boilers.

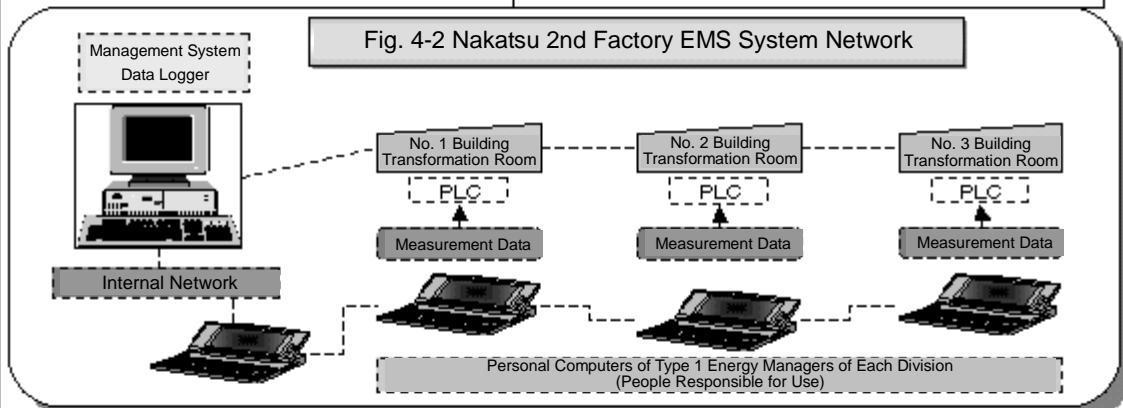
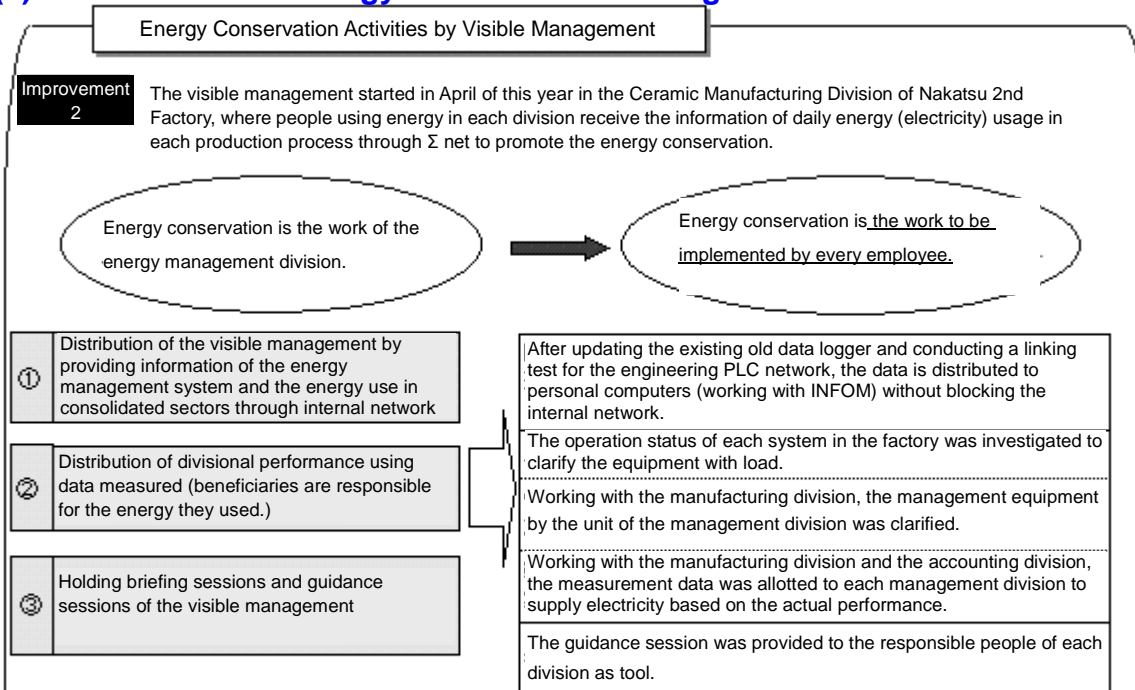
Improvement 1-2

To effectively use the water chiller and heater using the exhaust heat of the cogeneration system, the chilled and hot water piping of the water chiller and heaters of No. 1, 2 and 3 buildings are connected, and 3 water chiller and heaters (360 RT) and 1 chilled and hot water pump (30 KW) in the factory are additionally stopped.

Then air conditioning of the entire factory is performed by circulation with 1 chilled and hot water pump. In case there is trouble with the existing hot water boiler in operation, the heat sources of No. 1 and 3 buildings are connected and another hot water boiler is operated to protect the air conditioning of the precise measurement room, etc.

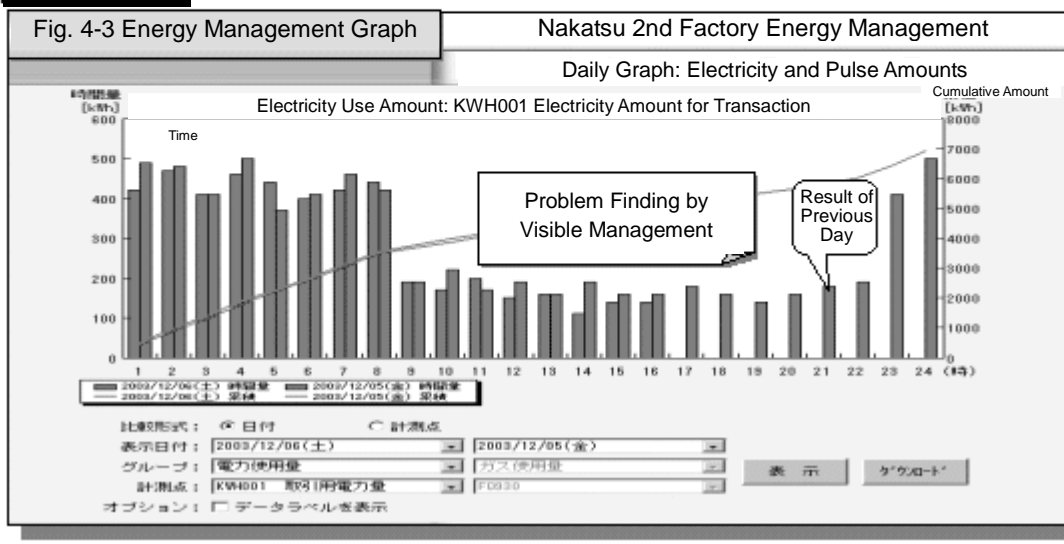


(2) Construction of Energy Conservation Management Network



Example of Data Use

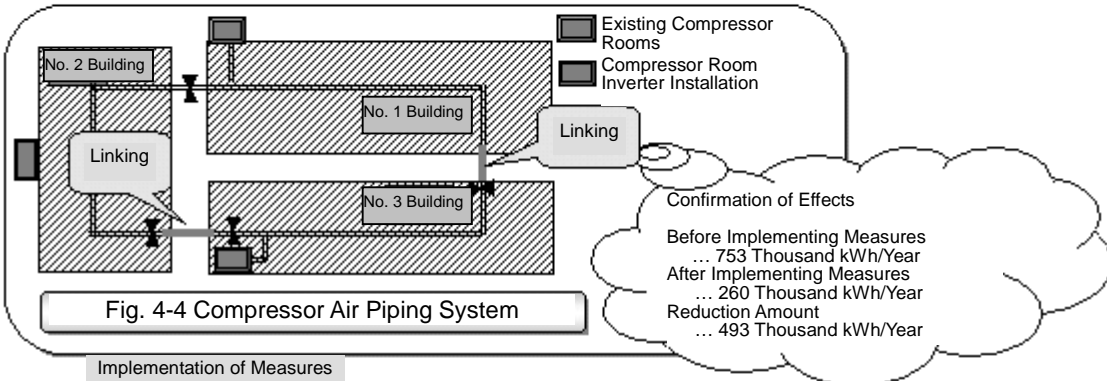
Distribution of Graphs as Visible Management of Energy Use by Each Division



(3) Cost Reduction by Implementing Energy Conservation Measures

[Implementation of Energy Conservation Measures] Reduction of Compressor's Electricity Amount by Integrating Air Piping into Loop

Improvement 3 As the production increased as the demand increased, the use of air also increased and additional compressors were needed. Meanwhile, the use of electricity also continued to increase. So when purchasing the compressors, we chose efficient models with inverter to limit the increase of electricity. We also tried to greatly reduce the use of air and electricity by integrating the air piping into a loop and by adjusting the valve operation on holidays mainly in No. 3 building.



Implementation of Measures

- | | |
|--|--|
| 1. To operate mainly the compressors with inverter. | One of 2 compressors of No. 3 building is operated continuously. The other compressor is operated during 8:30 to 17:00. |
| 2. To thin the operation of the compressors of No. 1 and 2 buildings to make their load maximum. | One compressor of No. 1 building or No. 2 building is operated. Time setting: 8:30 to 17:00. |
| 3. To change the way of the operation when the manufacturing division works on holidays. | All of the compressors of No. 1 and 2 buildings are stopped and the valves are closed after 17:00 of the day before holiday. Only one or two compressors with inverter are operated in No. 3 building. |

(4) Energy Conservation Awareness

Enhancement of Energy Conservation Awareness of Employees

Improvement
4

- (1) **To indicate energy unit price on the steps of the stairs.**
To enhance the energy conservation awareness by indicating the energy cost.
- (2) **To put up energy conservation bulletin board.**
To be placed around the entrance to the employee's locker room to show the cost reduction amount.
- (3) **To strengthen the energy conservation patrol.**
To inform responsible people of the problematic worksites with photo data and ask them to take action.
- (4) **To indicate the management values and the name of responsible people around the switches of the air conditioners.**
To clarify the management values and the responsible people (with photo).



(1) **Energy cost** indicated on the steps of the stairs



(2) Energy conservation bulletin board



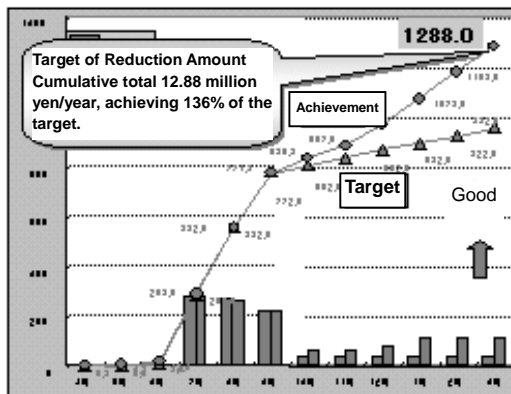
(3) Energy conservation patrol
The result check list is circulated.



(4) **Management values and responsible people are indicated** above the air conditioning switch.

5. Effects Achieved after Implementing Measures

(1) Effects Achieved after Implementing Measures

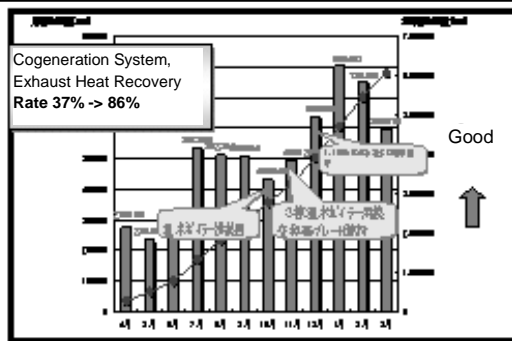


12.88 million yen, i.e. 136% of the target, was reduced by the energy conservation measures and other improvement, contributing to the improvement of the profit. (Fig. 5-1)

<Breakdown>

- By installing the heat exchangers in the hot water boiler system of No. 1 and 2 buildings to recover the exhaust heat and reduce the cost
Reduction of LPG use: 3.87 million yen/year
- Effective use of the water chiller and heater using the exhaust heat of the cogeneration system by linking the chilled and hot water piping
Reduction of LPG and electricity use: 1.89 million yen/year
- Reduction of electricity use by effectively operating the compressors with inverter in No. 3 building
Reduction of electricity use: 7.54 million yen/year

Fig. 5-1 Cost Cut by Energy Conservation Measures



Synergy Effect by Recovering Exhaust Heat

- As hot water was supplied to the air conditioning equipment which always uses exhaust heat of the cogeneration system, the exhaust heat recovery rate was improved.
(Recovery rate 37% -> 86%)
 Meanwhile, as the generator's jacket cooling water temperature was decreased (90 -> 80), **the risk of engine stop is avoided.**
- As the chilled and hot water piping of the water chiller and heater were linked, **the risk of trouble is avoided.** (Fig. 5-2)

Fig. 5-2 Cogeneration System, Exhaust Heat Recovery Rate

(2) Effects Achieved after Implementing Measures

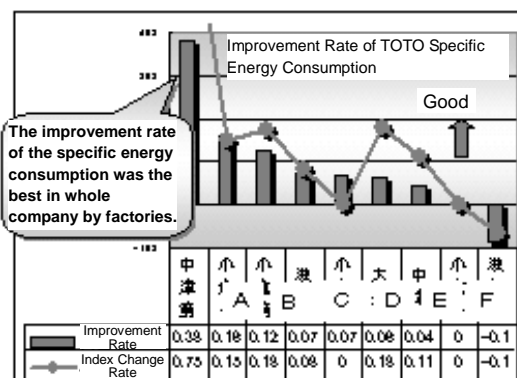


Fig. 5-3 Improvement Rate of Total Specific Energy Consumption of Company's Factories

The improvement rate of actual specific energy consumption was **38.3%**, greatly exceeding 20% or more as the target. It was **the best** in whole company by factories in FY2003. (Fig. 5-3)

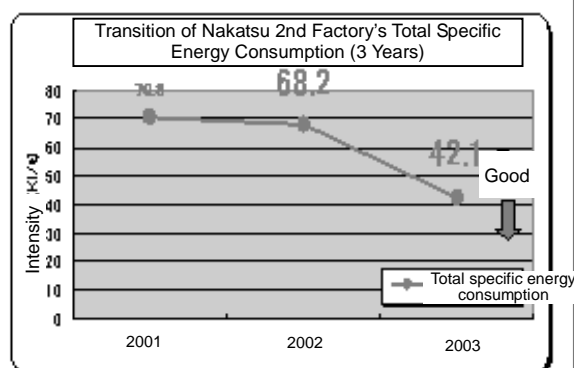


Fig. 5-4 Transition of Nakatsu 2nd Factory's Total Specific Energy Consumption

Total Improvement Rate of Specific Energy Consumption

38.3% (Achievement rate:153% of Target)

(Fig. 5-4)

6. Summary

- 1) We built a system for promoting the energy conservation activities in this factory and actively addressed many improvements in addition to the activities we had been doing previously. Especially, we were successful in recovering the waste heat of the cogeneration system, achieving 161% recovery rate.
- 2) To enhance the energy conservation awareness of each employee, we indicated the unit price of electricity, LPG, city water, etc. on the steps of the stairs at the entrance of the factory. With this easily understandable measure, everybody became conscious of the energy cost, so sufficient awareness effect was created. Furthermore, we posted the graphs showing monthly electricity use, LPG use or specific energy consumption at the entrance of the employee's locker room so that everybody can confirm the use of the energy.

7. Future Plans

- 1) Continual implementation of energy conservation activities
 - a. We will maximize the merits of the introduced cogeneration system by operating the generator on holidays and at night, while enriching the demand monitoring system. (Considering applying the UPS system, at night we will stop the generator always in operation.)
 - b. As horizontal deployment, we will implement the EMS (energy management system) for the use of water and enrich the "visible management".
- 2) We, as energy supply division, will closely communicate with the manufacturing division, as our customer, and organize a system which can supply energy at lower cost.