2005 Prize of Director General of Regional Bureau of Economy, Trade and Industry

Innovative Energy Conservation at Dye Works

Komatsu Seiren Co., Ltd., Negami Works
Hakuto Project

◎ **Keywords: Rationalization of fuel combustion, Rationalized conversion of heat into motive energy, etc. (Co-generation facility)**

◎ Outline of Theme

All personnel of the plant were united as one under the slogan of "one who controls steam controls energy conservation", in their effort to reduce energy consumption, primarily with boilers. This is because the contribution to energy conservation by reducing steam is significant, since much steam is used in production processes. This could be achieved by improving operating methods and converting facilities to energy conserving types. Furthermore, an Energy Conservation White Paper and an Energy Conservation Five Year Plan were formulated, which indicated energy consumption and proposed policies for undertaking energy conservation activities to the management and the plant. Furthermore, results announcement meetings and energy conservation study sessions for persons in charge at the plant were also conducted, bringing about a major success in implementation of energy conservation activities.

◎ Implementation Period of the Said Case

- Period Planning Period: December 2002 to September 2003.
- Measures implementation Period: February 2003 to the present time.
- Measures Effect verification Period: March 2003 to the present time.

Classifications of applicable business location:

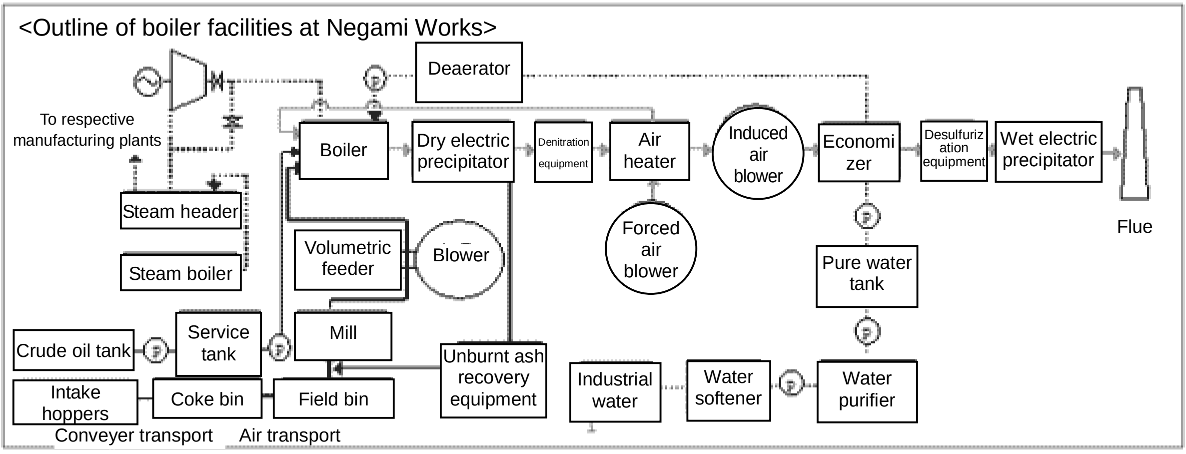
Heat:	Type 1 Designated Energy Management Factory.
Electricity:	Type 1 Designated Energy Management Factory.

◎ Outline of the Business Establishment

- Production items: Refining and dying of polyester materials, functional processing, synthetic leather production
- Number of employees: 900 persons
- Annual energy consumption (record for FY2004):

Oil coke:	28,959 tons
Grade A crude oil:	5,590 kiloliters
Electric power	
(purchased from Hokuriku Electric Power Co.):	10,718 kWh
Inhouse power generation:	36,528 kWh
Liquefied petroleum gas (LPG):	4,591 tons

◎ Process Flow of Target Facility



1. Reasons for Theme Selection

The dying industry is considered to be an industry that consumes a large amount of energy. Since energy conservation activities implemented at manufacturing plants significantly impact quality by altering processing conditions, not much progress had been made in the past in terms of improvements for energy conservation, because quality was a priority. In order to initiate innovative energy conservation in the company, we decided to take on the challenge of improving efficiency of boilers, which are on the supply side of energy and to spread the impact of activities based on this case example, so that energy conservation awareness can be spread throughout the company.

2. Understanding and Analysis of Current Situation

About 70 to 80 tons of steam is used at this manufacturing plant every hour. Majority of the steam, about 60 to 65 tons per hour, is generated by a boiler operating on mixture of oil coke and grade C crude oil (hereinafter referred to as "CP-65 electric power generation boiler). Any shortages are dealt with by using a grade C crude oil dedicated combustion boiler (steam boiler) to add more steam. Furthermore, back pressure turbines are installed on the CP-65 boiler, to generate up to a maximum of 6,300 kW of electric power.

A review on ratio of energy (crude oil equivalent) used at the manufacturing plant indicated that fuel (heavy oil and oil coke) used by boilers comprised 77 % or all energy consumptions.

For this reason the slogan, "one who controls steam controls energy conservation", was set up and strategies were formulated and implemented.

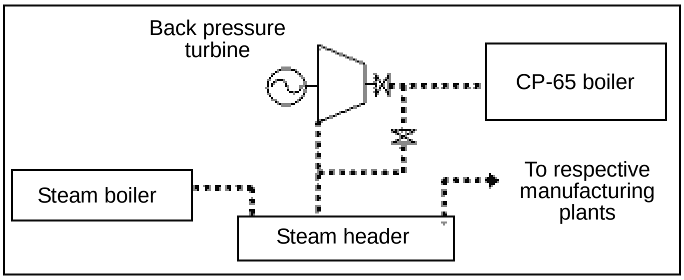


Figure 1: Schematic diagram of boiler turbine steam flow channels

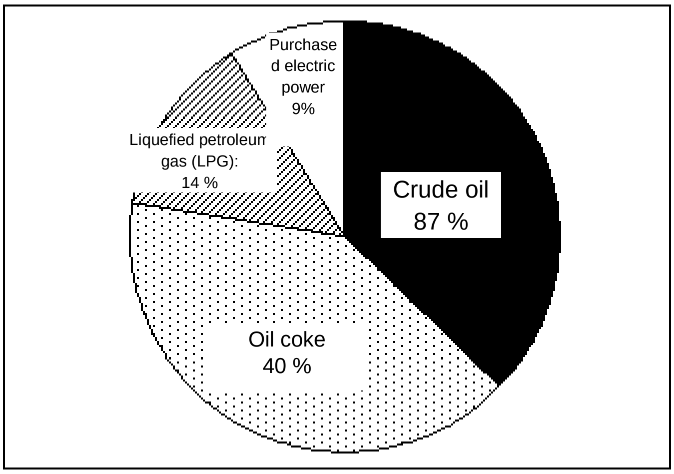


Figure 2: Energy consumption ratio

<based on record for FY2002>

3. Implementation Structure

The Environmental Energy Section played a central role in implementing activities of the project, since the primary concern of the project was with boiler related matters. Activities were implemented by coordinating efforts with respective manufacturing plants and the Production Control Division. Furthermore, it was decided to set the chain of command on this matter in such a way that reporting on details and effects of energy conservation activities are made to the top management directly by the Environmental Energy Section.

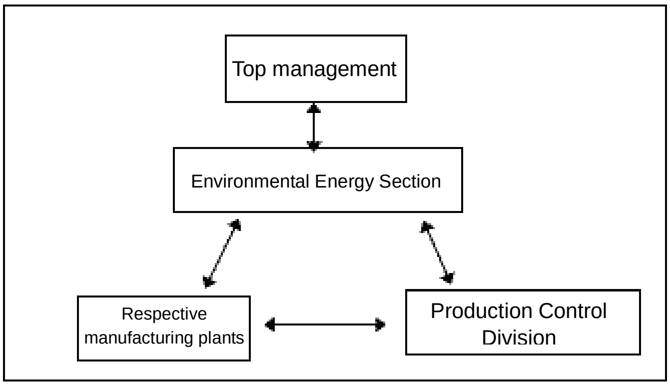


Figure 3: Organization for promoting energy conservation activities

4. Energy Conservation Measures

Boilers that use powder fuels, such as oil coke and coal, tend to have less efficient combustibility in comparison to those that use liquid or gas fuels, which is the reason why they are ordinarily considered to have poor boiler efficiencies. On the other hand their prices are more moderate and raising the consumption rate of oil coke brings about financial advantages to businesses, which consider it a strategy for cost reductions. We decided to take on the challenge of raising boiler efficiency and mixed combustion ratio of oil coke, in order to attain both energy conservation and cost reduction, which are two contradicting issues.

Furthermore, peak-cut electric power generation was also implemented at the same time with raised inhouse electric power generating efficiency, in order to reduce consumption of electric power purchased through subscription with the power grid.

(1) Targets Setting of Measures

Respective targets for individual strategies were set as following:

- Increase of CP-65 electric power generating boiler efficiency by 1 % (in comparison with figures of FY2002).
- Increase of inhouse electric power generating rate by 5 % (in comparison with figures of FY2002).

Accordingly, a reduction of energy by 1,000 kiloliters (crude oil equivalent) per year (2 % of overall consumption) was set as a target.

(2) Details of Measures

A. Activities for raising CP-65 electric power generating boiler efficiency

1) Activity for stabilizing supply of oil coke

The oil coke supply facility was reviewed and improved first. In the past, when the steam consumption at the manufacturing plant fluctuated, clogging occurred due to bridging in the fine powder tank, which interrupted constant supply of fuel to the boiler, resulting in unstable flames and temporary reduction in boiler efficiency.

Since the drop structure is used to supply oil coke from the fine powder tank to the volumetric feeder, a bridge is formed during operations when an abundant amount of oil coke with high degree of moisture percentage is left as they are in the facility. It was determined that such condition leads to insufficient supply. An improvement was made by installing a rotary valve immediately below the tank, in order to supply required quantities in small increments to facilitate smooth supply of fuel.

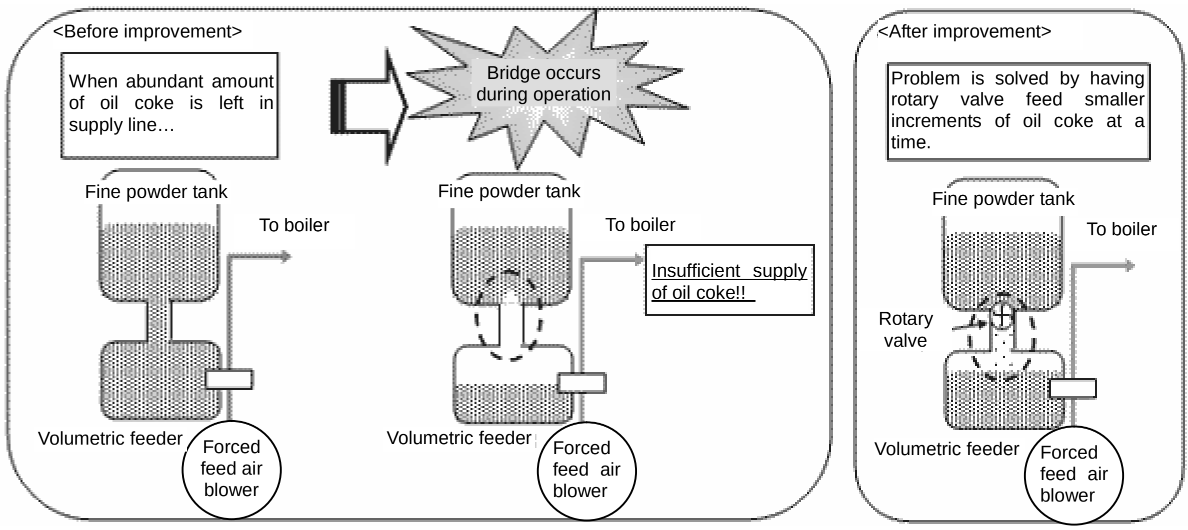


Figure 4: Schematic diagram of problem and modification pertaining to supply of oil coke

2) Improving oil coke grain size

Oil coke is ground into fine particles by a grinder (mill) and supplied to the boiler. The issue pertaining to increased combustibility of oil coke was dealt with by reducing grain size of pulverized powder even finer than before.

A review of the structure of grinder revealed, that the grinder was structured in such a way that only oil coke ground to smaller grains by the mill were sent to the powder tank through the separator section at the top, while the remaining oil coke of larger grains were ground again in the mill section. For this reason, those of medium grain sizes were retained in the external peripherals of the separator, resulting in increasing loss of pressure and deterioration in classifier efficiency. Furthermore, there were also cases where grains of smaller sizes were also dropped into the lower section of the mill and excessively ground, when use of oil coke increased (fluctuating fineness of pulverization).

The structure was improved to increase the classifier efficiency by facilitating smoother flow of air, through cooperation with the equipment manufacturer. This resulted in the elimination of interference by rough powders separated from ground particles that enter into the separator, thereby increasing classifier efficiency.

Flames of the burner could then be adjusted easily, even when load on the boiler fluctuated. This also resulted in improved combustibility inside the furnace. It also became possible to temporarily supply a large amount of oil coke to the boiler.

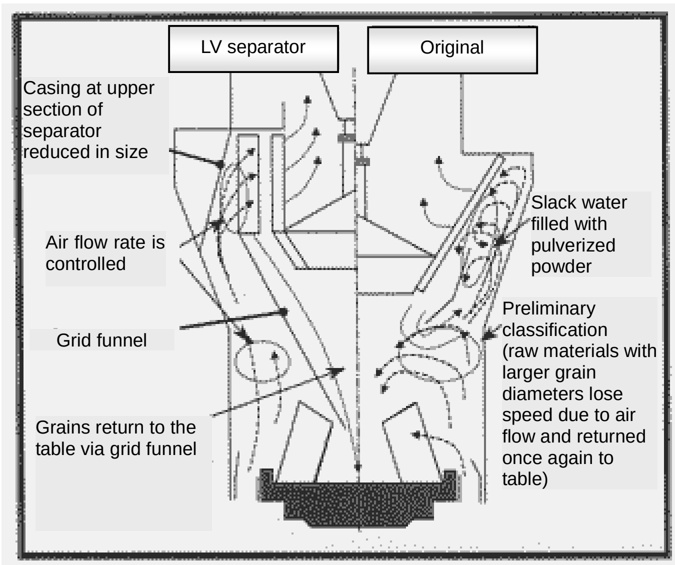


Figure 5: Schematic diagram of separator before and after improvement

	Proportion of pulverized grains passing through the 200 mesh structure
Before modification	96.0 %
After modification	98.4 %

Table 2: Before and after modification of separator

Grain size of oil coke

3) Activity for effective use of fuel (implementation of unburned oil coke recovery facility)

Carbon that was not properly combusted comprised 77.3 % of combustion ash. A consideration was made for effective use of fuel and reduction of waste materials, by determining whether or not it would be possible to separate those with higher carbon contents from the rest of the ash and reused. Ash was classified and constituents were analyzed, which revealed that a large amount of carbon contents was included in coarse constituents. The amount of unburnt carbon in ash was reduced from 77.3 % to 44.1 % by recovering these constituents and using them as fuel, thereby realizing effective use of oil coke.

Table 3: Grain diameters of combustion ash

(Before implementation of recovery facility)

		Average grain diameter µm	Unburnt carbon constituents %	Ash components %
Combustion ash		45.0	77.3	12.4
Classification	Fine powder constituents	27.8	59.0	26.8
	Coarse powder constituents	50.7	79.3	7.1

→ Recovery & reuse

(After implementation of recovery facility)

	Average grain diameter µm	Unburnt carbon constituents %	Ash components %
Combustion ash	28.1	44.1	44.8

4) Reducing steam loss in boilers

When the steam load dropped all of a sudden during night at the manufacturing plant, the adjustment of fuel for boiler could not keep up with the change and resulted in a rise of back pressure. Steam had to be released into the atmosphere to regulate the pressure. In order to reduce losses arising from this release into the atmosphere, the control method of regulating valve for steam supplied to turbines was changed and improvement was made to prevent back pressure from rising due to load fluctuations. This led to zero release of steam to the atmosphere and significantly reduced the amount of steam used in the boiler system.

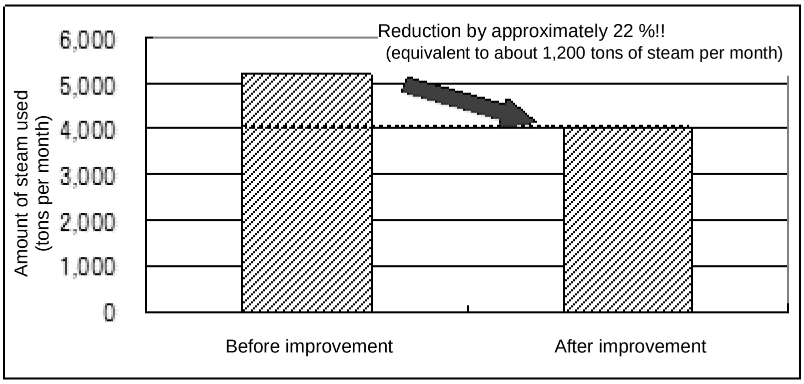


Figure 6: Amount of steam used by boiler system

5) Activity for raising supplied water temperature by implementing high efficiency economizer

An economizer of glass-tube type had been in use for many years, but since the glass can crack and the Teflon tube inside the casing may be damaged when the temperature of the exhaust gas rises, it often had to be showered with water continuously in order to regulate temperature of the glass tube and to keep it clean. For this reason, the outlet temperature of water from the economizer rose only as high as 65 degrees Celsius. The replacement of the economizer with the type that uses a heat exchanger tube with Teflon coating on the SUS tube enhanced the strength and eliminated the need to shower the economizer with water for the purpose of cooling. This resulted in an improved heat recovery rate, with the outlet water temperature of economizer rising above 80 degrees Celsius. Furthermore, by also narrowing down the angle of the flushing nozzle used for cleaning with water at the same time from a wide angel (90 degrees) to a narrower angle (30 degrees), soiling accumulating deeper inside could be removed, resulting in improvement of cleansing effect and shortening of cleaning time. The number of nozzles was increased by three in order to compensate for the narrowing of spraying angle.

6) Unifying internal temperature of boiler furnace

The thickness of fire resistant bricks on the wall surface of the boiler was increased by 30 mm during scheduled inspections of the boiler to unify the temperature inside the furnace and also at the same time prevent thermal radiation. Furthermore, maintenance cleaning inside the boiler had been conducted twice a year for many years. Due to the increased ratio of oil coke in the fuel however, the frequency of cleaning that also includes verification of effects on the interiors of the boiler furnace, was increased to four or five times a year.

The fuel mixture combustion ratio of oil coke in the fuel was raised in phases while implementing measures described above. We were also told during this process by the boiler manufacturer, that since they had no experience in raising oil coke ratio this far, they could not provide us with any guarantees for oil coke ratio of 80 % or more. We still pressed on with this challenge, analyzing the status as we continued and were able to establish a combustion method that involves oil coke ratio of 95 % or more. This effort led to the improvement of the boiler efficiency. Furthermore, oil coke was pulverized to raise the fuel mixture combustion ratio of oil cokes, which led to the increase of the concentration of carbon dioxide in the boiler combustion chamber. Carbon dioxide has a characteristic of absorbing infrared rays, which is a reason that it causes global warming. Since the coefficient of thermal transmission by radiation increases with the increased amount of carbon dioxide, the boiler efficiency was increased by 3 %, which resulted in a reduction of carbon dioxide emission per ton of steam. To balance off these measures, environmental facilities were also enhanced at the same time in order to ensure the implementation of a comprehensive environmental conservation strategy.

Table 4: Table of constituents in oil coke and grade C crude oil

	C %	H %	O %	S %	N %	Ash components %	Moisture components %	Calorific value kj/kg	Carbon dioxide after combustion %
Oil coke	86.2	3.9	0.5	5.0	2.8	0.7	0.9	35,169	18.3
Grade C crude oil:	85.8	11.2	-	2.5	0.28	0.02	0.02	41,449	15.7

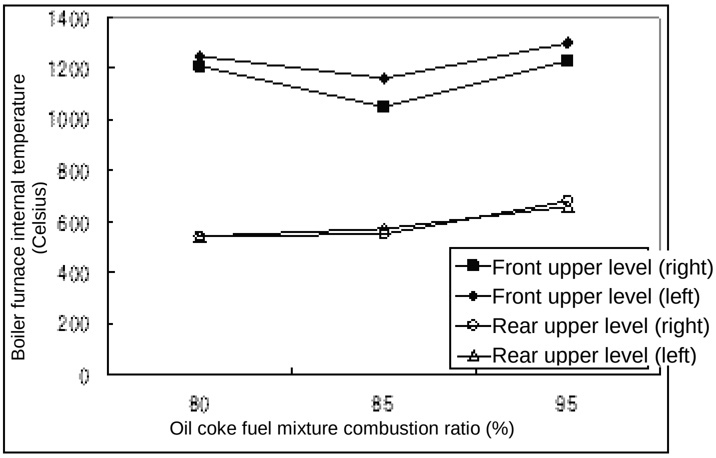


Figure 7: Internal temperature of boiler furnace

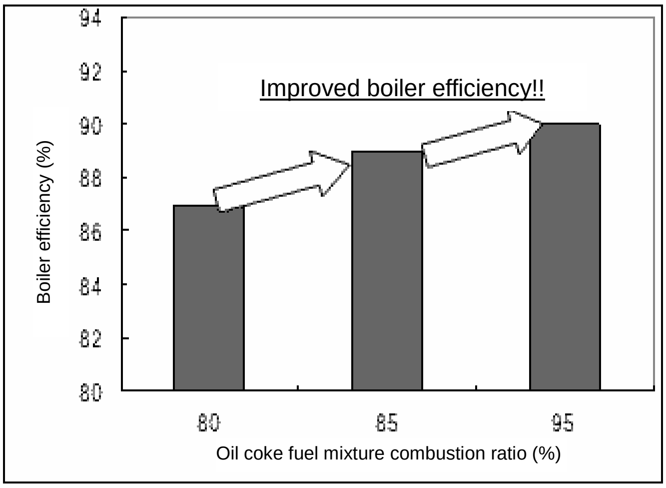


Figure 8: Boiler efficiency

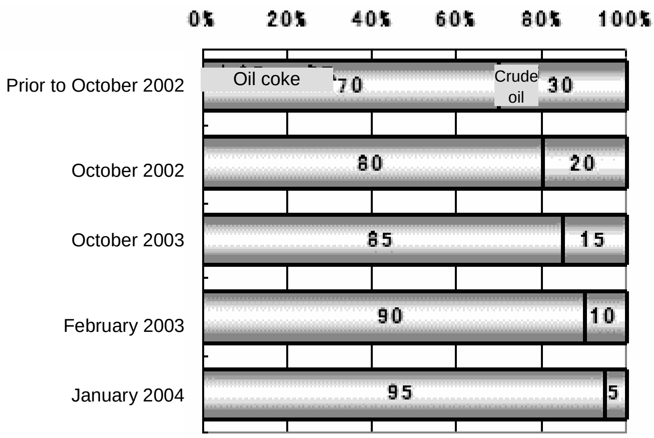


Figure 9: Transition of fuel mixture ratio for oil coke and grade C crude oil used in CP-65 electric power generating boiler

Table 5: Generation of carbon dioxide per unit amount of steam

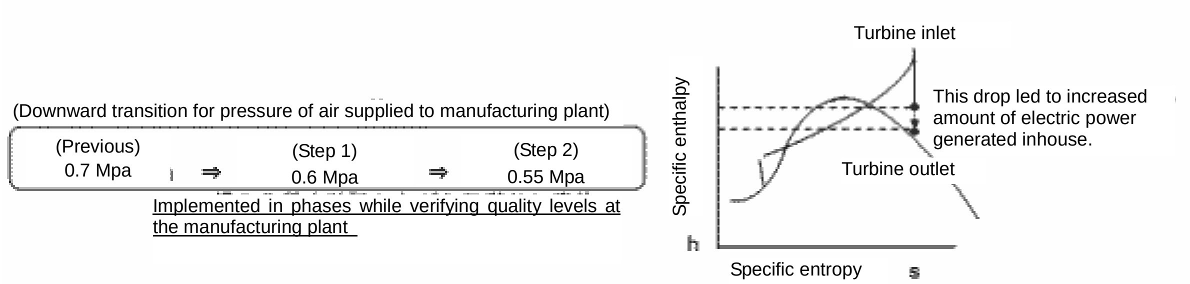
Oil coke fuel mixture combustion ratio	80 %	85 %	95 %
Generation of carbon dioxide per ton of steam (tons of carbon dioxide per ton of steam)	0.29	0.28	0.28
Boiler effectiveness	87 %	89 %	90 %

B. Increased inhouse electric power generating efficiency

1) Considerations on air supply for superheated steam and lowering of air supply pressure at the manufacturing plant

The steam used at the manufacturing plant is a saturated aqueous vapor, supplied to the manufacturing plant by converting superheated steam into saturated aqueous vapor by spraying water to the exteriors at the turbine outlet. Consideration for supplying superheated steam was made in the past, but since there were machines among manufacturing plant facilities that had restriction on pressure and subject to pressure control, we had to abandon the idea as under such circumstances we were unable to stabilize quality level with some of the equipment. We conducted repeated tests on facilities that we had problem with previously in order to once again consider means to supply superheated steam. We were able to establish a control method for using superheated steam and it became possible for us to supply superheated steam to the manufacturing plant.

Superheated steam contain more heat than saturated aqueous vapor of same pressure, making it possible to lower the steam pressure supplied to the manufacturing plant and have heat drop at the turbine, which resulted in increased amount of electric power generated inhouse.



2) Increased amount of inhouse electric power generation and reduced amount of electric power purchased from power grid through improvement of equipment startup method

The manufacturing plant operates on weekly schedule, with the furnace fired up at the beginning of the week and turned off over the weekend. The amount of electric power purchased from the power company was peaking either at the beginning of the week or on the weekend. An investigation on the status at the beginning of the week indicated that the steam boiler was put into operation to provide for the urgent demand, which occurred as the manufacturing plant temporarily took in steam when production facilities were all turned on at the same time. Once the demand stabilized, the CP-65 electric power generating boiler was started up and therefore also the turbine operation. We changed this so that from the start the CP-65 electric power generating boiler can by itself respond to the load of the manufacturing plant with the required amount of steam in a sequential manner, then later on also turn on the electric power generator at the same time in order to respond to the electric power needs. The amount of utility use per hour by the facilities at the manufacturing plant was investigated, in order to set start up timing for each individual facility based on the amount of utility used. A work procedure was prepared and explanations were provided to the General Manager of the manufacturing plant, which included descriptions on benefits that can be gained through implementation of the work procedure, to ensure that the procedure will be thoroughly implemented at work sites.

This made it possible to fire up only one boiler and also in a smooth manner, to operate the turbine and to reduce the amount of electric power purchased from the power grid.

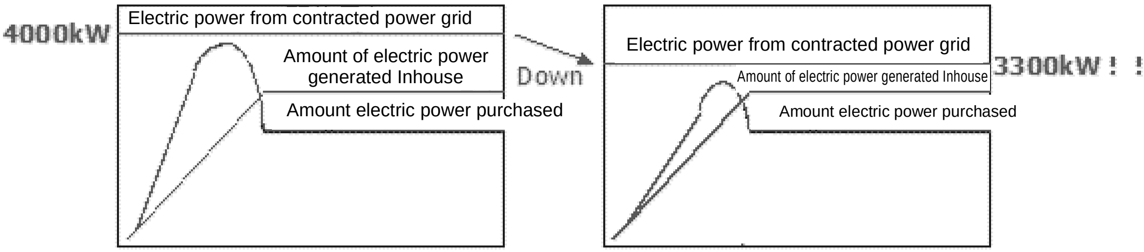


Figure 10: Typical diagram indicating peak in amount of electric power purchased at beginning of week

We were able to increase the ratio of electric power generated inhouse for electric power used, by implementing the aforementioned strategy.

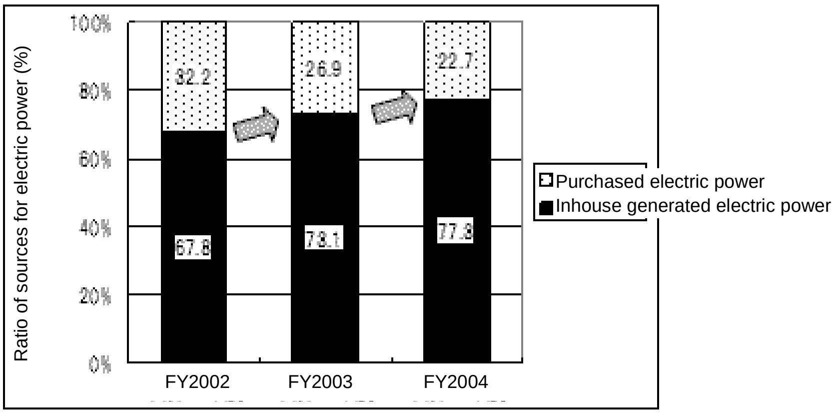


Figure 11: Transition of proportion comprised by inhouse generated electric power

C. Energy conserving activities for incidental facilities

Energy saving types of incidental facilities were selected and installed for the boiler.

Table 5: Comparison of ordinary type and energy saving type fans (of same capacity)

	Forced air blower	Induced air blower
Ordinary type	240 kW	390 kW
Energy saving type	210 kW	315 kW
Financial benefits	JPY1.1 million per year	JPY2.9 million per year

5. Effect Achieved after Implemented Measures

We were able to reduce energy consumption in terms of crude oil by 1,891 kiloliters per year, by implementing strategies to raise the boiler efficiency and inhouse electric power generating efficiency. We were also able to significantly reduce energy costs, by JPY158.9 million per year (2.3 recovery years), by increasing boiler efficiency and oil coke fuel mixture combustion ratio at the same time.

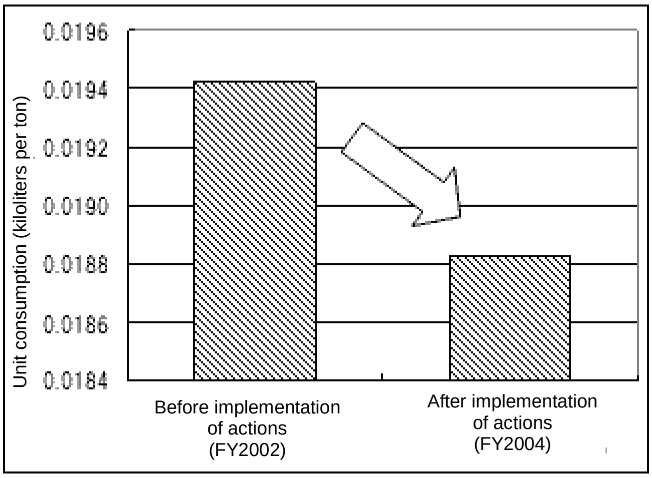


Figure 11: Effect of reduction in energy consumption unit (heat & electric power)

Table 6: Energy reduction effects

Details of implemented actions	Energy reduction effect (crude oil conversion)	Monetary value of effects of actions
Increased boiler efficiency	846 kiloliters per year	JPY115.6 million per year
Increased amount of electric power generated inhouse	780 kiloliters per year	JPY30.6 million per year
Implementation of energy conserving facilities	170 kiloliters per year	JPY4.0 million per year
Reduced amount of steam losses	80 kiloliters per year	JPY2.9 million per year
Others	15 kiloliters per year	JPY5.8 million per year
Total	1,891 kiloliters per year	JPY158.9 million per year

6. Spread Activities Impacting the Management and Manufacturing Plant

Following activities were implemented, in order to increase awareness of energy conservation in the company, as well as to spread the impact of actions of this case example taken by our group:

(1) Preparation of the Energy Conservation White Paper and provision of explanations on its contents (for the management and General Manager of manufacturing plant)
Energy consumption at individual manufacturing plants, transition of unit consumptions, as well as proposals for future energy strategies and reduction targets.
(2) Disclosure of environment surrounding energy and case example for energy conserving activities conducted in the company (for entire manufacturing plant)
Introduction of global energy trends and boiler related activities that breakthrough current conditions.
(3) Energy conservation lecture for work site facilities (for persons in charge at work sites)
Explanation provided from perspective of energy for individual equipment and provision of hints for energy conservation.

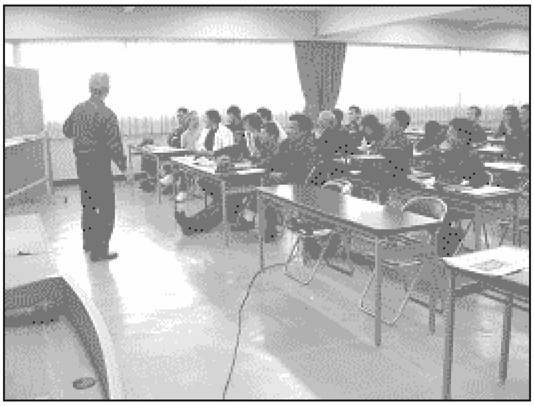


Figure 12: Energy conservation lecture provided to persons in charge at work sites (implemented on 13th, 20th and 27th of May)

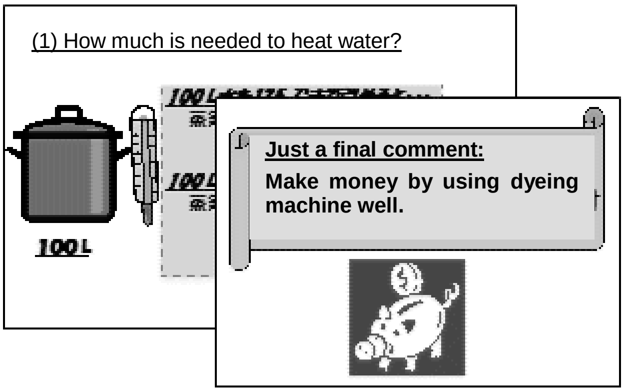


Figure 13: Energy conservation lecture materials (portions)

7. Summary and Future Plans

We were able to reduce annual energy equivalency of 1,891 kiloliters in crude oil equivalent, by implementing energy conservation strategies to the boiler, which is on the energy supply side. Efforts are currently being made to spread the impact of this energy conservation activity and we intend to promote a ban on consumption of energy in wasteful manner at work sites, in other words consumption without contribution to production activities at the manufacturing plant, implement repairs on leaks and reduce wasteful lighting on the premises, in order to reduce wastefully used energy.