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Energy Conservation and Natural Resource-saving through the Introduction of Continuous Cast Hot Billet Direct Rolling and a High Performance Industrial Furnace

Nakayama Steel Products Co., Ltd.
Direct Rolling Process Project Team

◎ **Keywords: Prevention of energy loss due to radiation, convection, conduction, thermal resistance, etc. (Prevention of heat loss due to radiation, convection, conduction, etc.)**
Rationalization of fuel combustion, Recovery and use of waste heat

◎ Outline of Theme

By conveying hot billet manufactured from ~~on~~ a continuous casting line directly to the rolling line entrance with a roller table, it is possible to restrict the temperature drop to the minimum and carry out the rolling of the billet as it is without further heating. Billet that can not be directly conveyed has its temperature raised using a high performance industrial furnace with regenerative burners and ceramic heat insulating materials, and is rolled at a low temperature. Using a consistent operation management system for both the steelmaking and rolling lines, it was succeeded in attaining full production performance from the operation start month. A large energy conservation was realized due to a reduction in the fuel used, together with a saving of natural resources caused by reductions in scale and in auxiliary materials.

◎ Implementation Period of the Said Example

October 2004 – July 2008

- Project Planning Period October 2004 – August 2006 Total 23 months
- Measures Implementation Period September 2006 – April 2008 Total 20 months
- Measures Effect Confirmation Period January 2008 – July 2008 Total 7 months

◎ Outline of the Business Establishment

- Items Produced　Hot rolled deformed steel bars for concrete reinforcement (D16-D51)
- No. of Employees　175 persons
- Type 1 designated energy management factory

◎ Process Flow of Target Facility

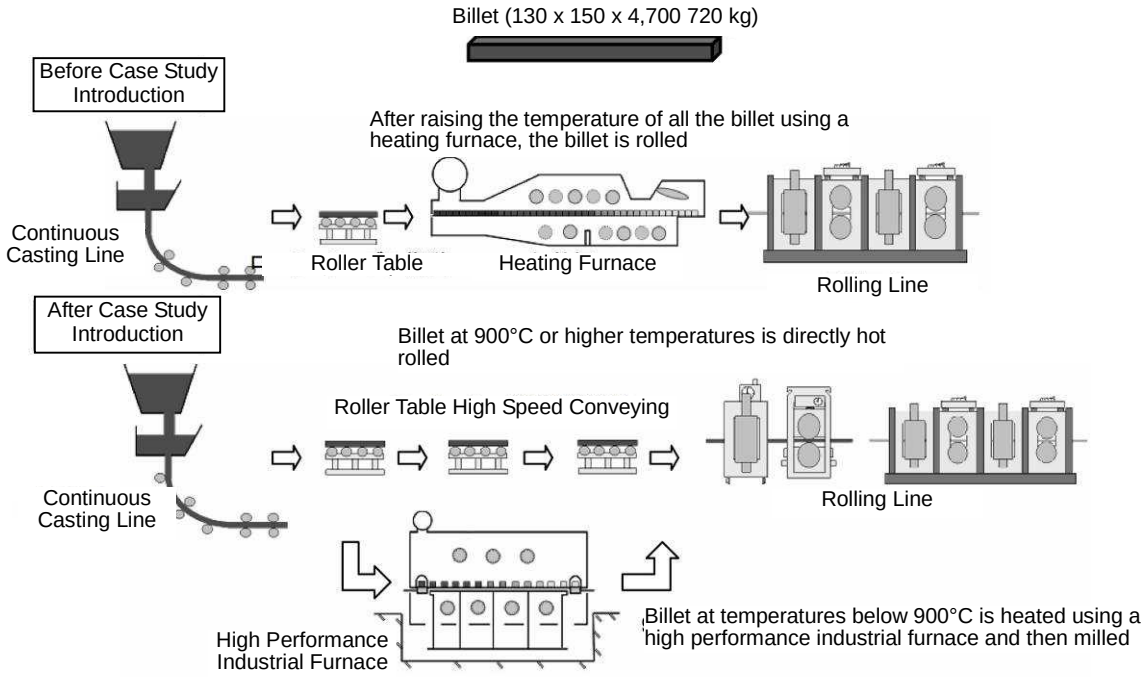


Fig. 1 Target Equipment Process

1. Reasons for Theme Selection

Taking into consideration the coming into effect of the Kyoto Protocol relating to the prevention of global warming, the revisions to the Energy Conservation Law and the latest various circumstances surrounding energy, the rationalization of energy use by companies will require even greater efforts.

In this company's production process, in order to reduce the large amount of energy consumed by the heating furnace fuel gas, the effective utilization of hot billet and improvement of the combustion efficiency was carried out to achieve a large energy conservation effect.

In addition, the surface scale (hot billet surface iron oxide) and auxiliary materials were reduced, achieving a natural resource-saving effect.

2. Progress of Activities

(1) Implementation Structure

With the objective of realizing consistent operation management of both the steelmaking and rolling lines, a project team (Direct Rolling Process Project Team: CAP.PT) was established, consisting of persons from throughout the company.

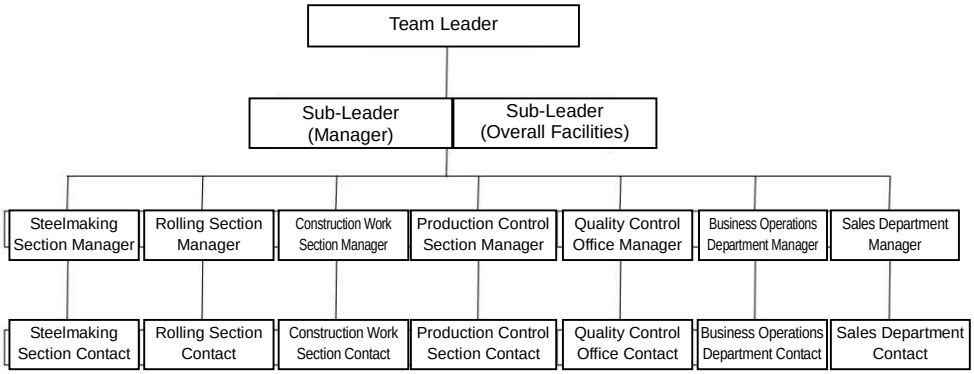


Fig. 2 Program Structure

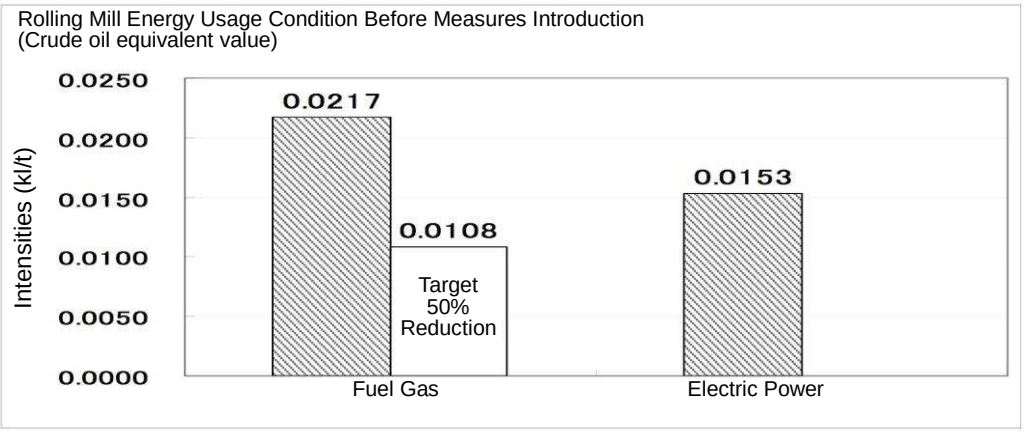
(2) Understanding of Current Situation

Before the measures introduction in the rolling mill (fiscal year 2005), the energy usage actual results were as shown in Table 1.

Table 1 Rolling Mill Energy Usage Amounts before Measure Introduction

Item		Units	Actual Results before Introduction	Crude Oil equivalent Amount (kl)	Specific Energy Consumption(Crude Oil equivalent Amount (kl/t)
Rolling	Main Machine Electric Power Amount	1,000 kWh	15,374	3,726	0.0099
	Related Electric Power Amount	1,000 kWh	8,365	2,028	0.0054
	Fuel Gas	1,000 Nm³	7,043	8,177	0.0217
Total				13,931	0.0370

Graph 1 Rolling Mill Energy Usage Condition Before Measures Introduction



(3) Analysis of Current Situation

1) Temperature reduction due to billet conveying

Although the temperature of the billet manufactured from ~~on~~ the continuous casting line is approximately 1,000℃, around 140 seconds are required to convey it to the entrance to the heating furnace. During this time, there is no heat insulating cover or other device, so that the billet temperature drops to approximately 800℃.

2) Capacity of the rolling mill motors

There are 16 rolling mill units, with a total motor capacity of 7,230 kW.
In order to roll the deformed steel bars (D16-D51) from the billet having a cross section of 130 x 150 mm, a rolling start temperature of approximately 1,130℃ is required.

3) Heating furnace current specifications

The heating furnace effective furnace length is 22.5 m. The 15 burner units realize a total of 128,510 MJ/hr, and the furnace has a capacity to raise the temperature of room temperature billet (cold charge) to 1,130℃, allowing extraction of 90 t/hr.
This capacity exceeds the requirements when using hot billet.

4) Heating furnace exhaust gas waste heat recovery

Although the combustion air used in the heating furnace burner combustion has its exhaust

gas waste heat utilized by a heat exchanger, the temperature recovered is approximately 430℃.

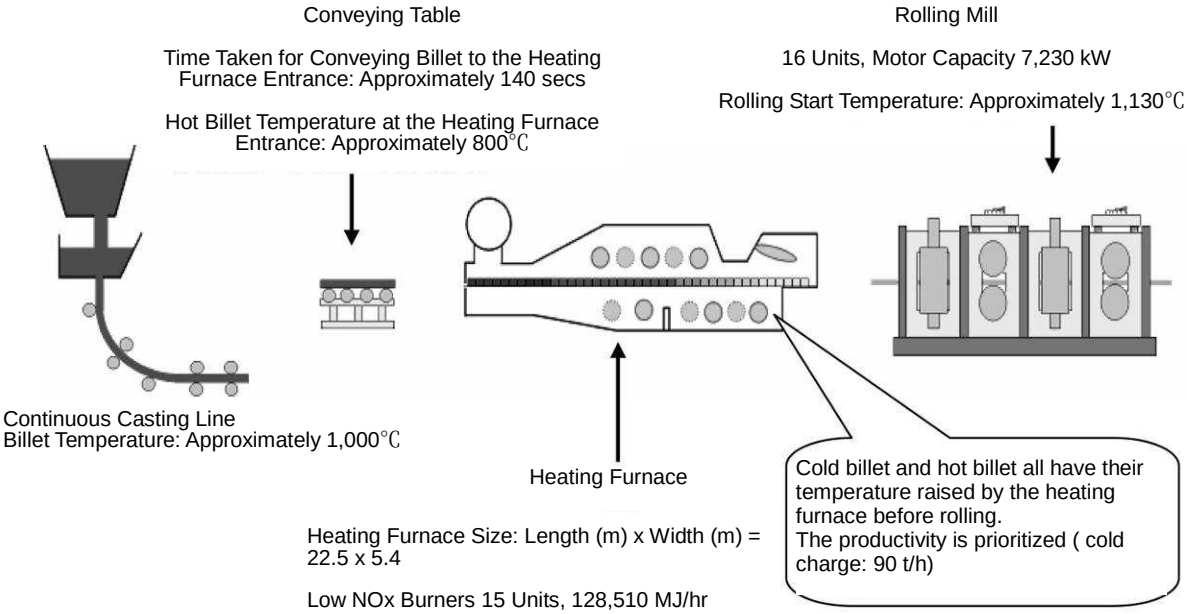


Fig. 3 Overview of Target Equipment Processes before Case Study Introduction

(4) Target Settings

A 50% reduction in the specific fuel gas consumption was aimed for, a lower level than other companies in the same industry incorporating the latest equipment.
The actual results (Crude oil equivalent) before the introduction (fiscal year 2005) of 0.0217 kl/t were to be reduced to 0.0108 kl/t.

(5) Problem Points and Their Investigation

1) Problem points

a. Because approximately 140 seconds are required for conveying billet from the continuous casting line, the billet temperature when introduced to the heating furnace is 800℃ or less.
b. Rolling Mill Motor Capacity
   There are 16 rolling mills with a total motor capacity of 7,230 kW. This capacity is required to achieve the rolling start temperature of approximately 1,130℃.
c. Heating Furnace Current Specification
   The temperature of all the billet for milling is raised using the heating furnace. This

specification gives priority to productivity.

d. The heating furnace exhaust gas waste heat is recovered using a recuperator (approximately 430℃), but this is insufficient.

2) Measure details

a. Shorten the conveying time from the continuous casting line in order to supply billet at a 900℃ or higher temperature directly to the rolling line.
b. In order that the rolling mill motor capacity will allow rolling at a temperature of approximately 900℃, increase the number of rolling mills and further boost the existing motor power.
c. Select a high performance industrial furnace to be newly installed that has a specification which prioritizes energy conservation, and only raise the temperature of billet that is below a temperature of 900℃.
d. Newly install the high performance industrial furnace with regenerative burners to increase the heat efficiency.

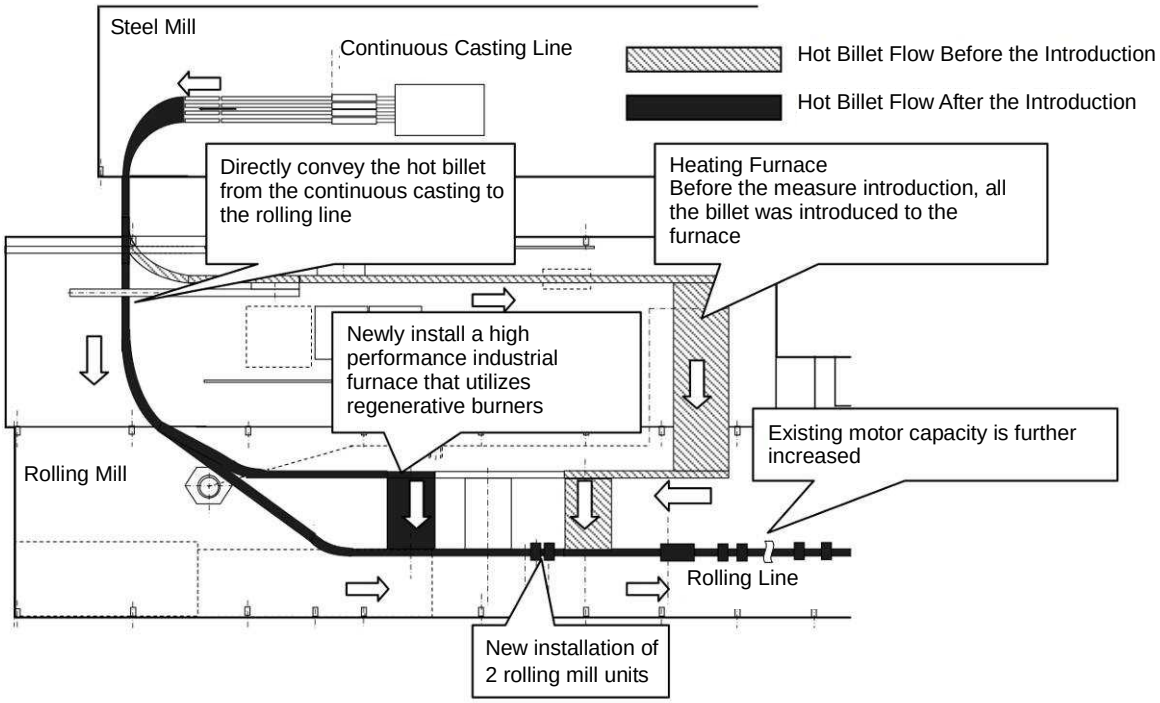


Fig. 4 Investigation Details (Mill layout diagram)

(6) Details of Measures

Table 2: Main Item Current Situation and Measures

No.	Item	Current Condition	Measure
1	Billet Conveying Speed	1.0 m/s	2.0-3.0 m/s
2	Billet Conveying Time	140 secs	60 secs
3	Billet Temperature after Conveying	Around 800℃	Around 900℃
4	Rolling Start Temperature	Around 1,130℃	Around 900℃
5	Number of Rolling Mills	16 Units	18 Units
6	Rolling Mill Motor Capacity	7,230 kW	10,390 kW
7	Heating Furnace No. of Burners	15 Units	7 Pairs
8	Heating Furnace Burner Capacity	128,510 MJ/hr	47,579 MJ/hr
9	Heating Furnace Effective Length	22.50 m	7.75 m
10	Heating Furnace Waste Heat Recovery	Recuperator	Honeycomb Type Regenerative Burners
11	Heating Furnace Productivity	90 t/hr	40 t/hr
12	Heating Furnace Usage Percentage	100%	30%
13	Direct Rolling	None	70%

1) Temperature reduction due to billet conveying

By setting the billet conveying speed 2-3 times faster to reduce the conveying time to half or less, the hot billet temperature drop is restricted to a minimum.

2) Rolling mill motor capacity

By increasing the number of rolling mills and increasing the power of the existing rolling mill motors (to 144%) to allow the rolling start temperature to be made around 900℃, it is possible to carry out direct rolling without raising the temperature and thereby achieve a large energy conservation effect.

3) Heating furnace specification

The burner capacity effective furnace length is reduced to change from a specification that prioritizes productivity to one that prioritizes energy conservation.

4) Heating furnace exhaust gas waste heat recovery

The high performance industrial furnace to be newly installed utilizes honeycomb type regenerative burners.

5) The direct sending hot rolling (non-heating) percentage (known below as the direct sending rate) is planned to be 70% or more.

In order to realize this target, a production system was established that would improve the direct sending rate to match the production conditions.

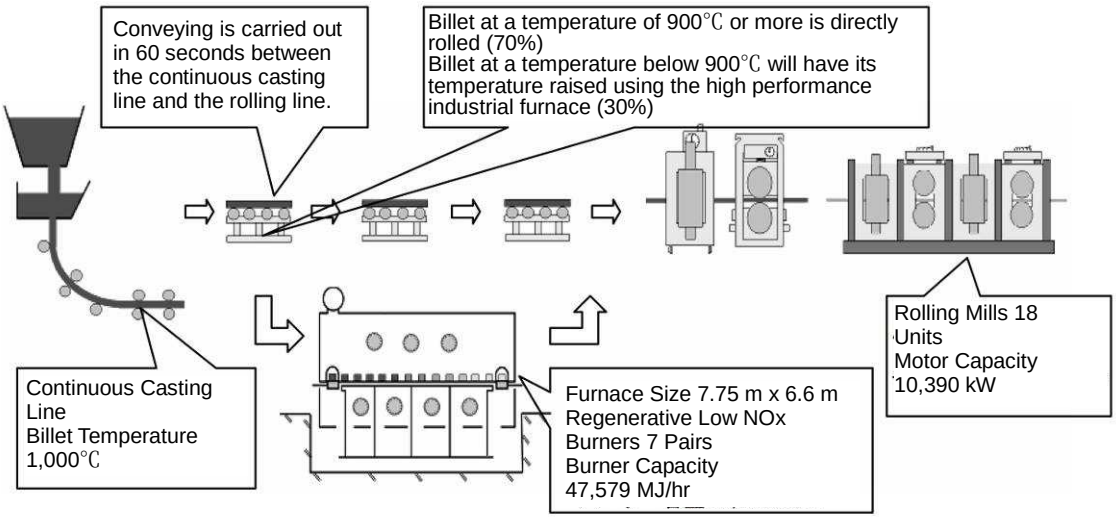


Fig. 5 Overview of Target Equipment Processes after Case Study Introduction

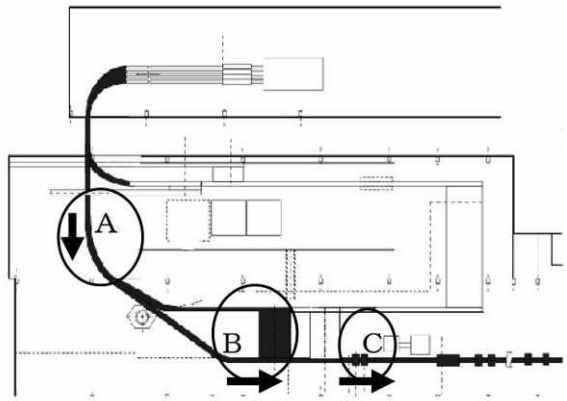
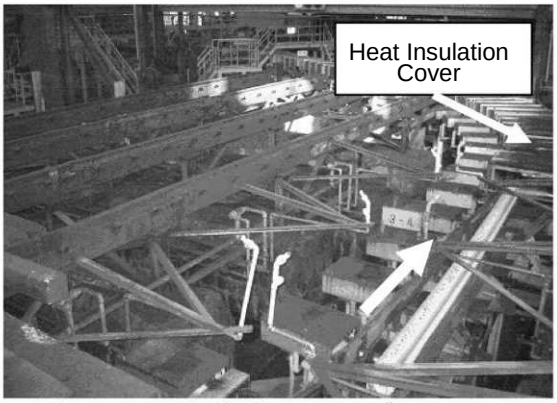
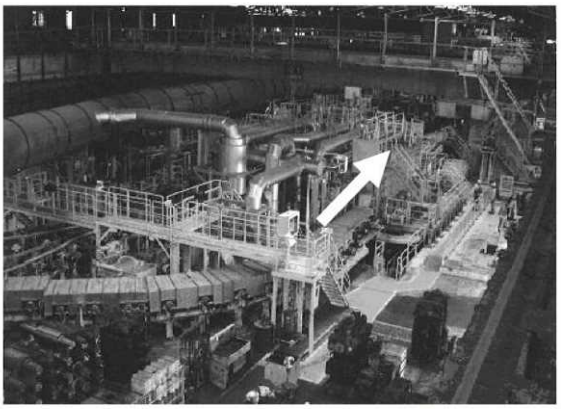


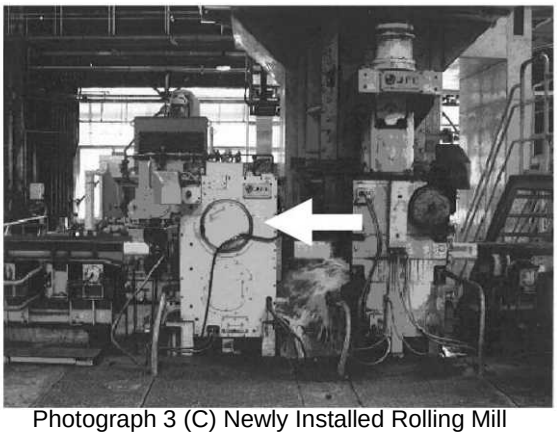
Fig. 6 Photograph Position Explanatory Diagram



Photograph 1 (A) Direct Sending (Conveying) Table



Photograph 2 (B) Newly Installed High Performance Industrial Furnace



Photograph 3 (C) Newly Installed Rolling Mill

(7) Effects Achieved after Implementing Measures

1) Energy intensities

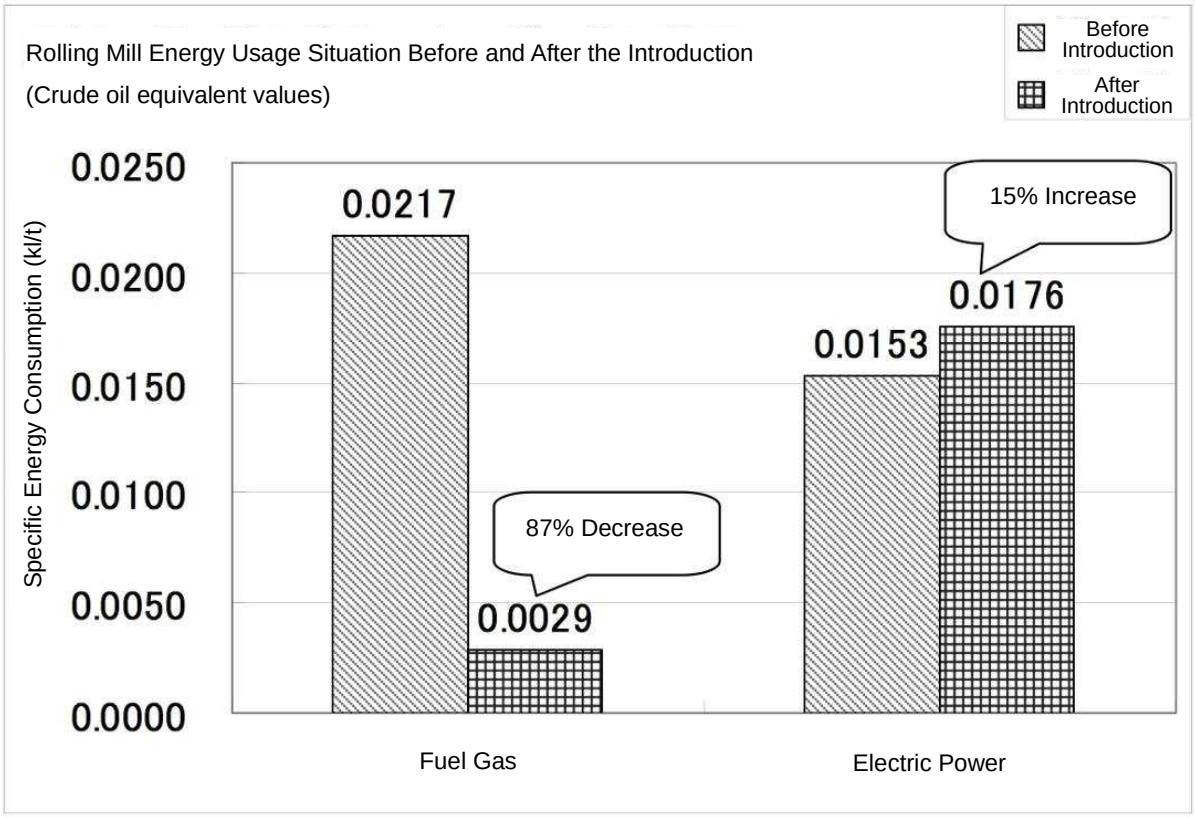
a. It was possible to reduce the specific fuel gas consumption by approximately 87%.
b. It was possible to reduce the rolling mill overall specific energy consumption by approximately 45%.
c. Due to the reduction of the temperature raising work, it was possible to reduce the work of three persons.

Table 3 Comparison of Energy Intensities Before and After the Introduction

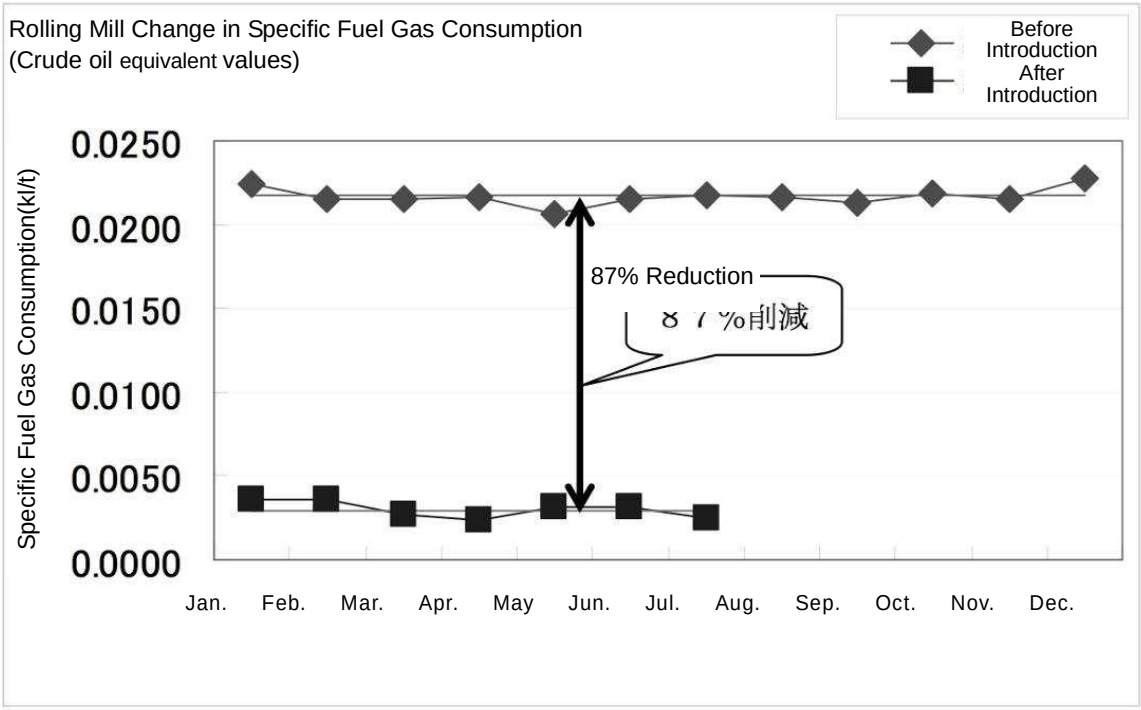
Item		Actual Results Before Introduction		Actual Results After Introduction	
		Crude Oil equivalent Amount (kl)	Specific Energy Consumption(Crude Oil equivalent Amount (kl/t))	Crude Oil equivalent Amount (kl)	Specific Energy Consumption(Crude Oil equivalent Amount (kl/t))
Rolling	Main Machine Electric Power Amount	3,726	0.0099	4,448	0.0118
	Related Electric Power Amount	2,028	0.0054	2,186	0.0058
	Fuel Gas	8,177	0.0217	1,093	0.0029
Total		13,931	0.037	7,727	0.0205

The actual results after the introduction were calculated as an annual crude oil equivalent amount from the specific energy consumption actual results for the 7 months after the introduction (January to July 2008) using the actual production amount (376,929 t/year) before the introduction.

Graph 2 Rolling Mill Energy Usage Situation Before and After the Introduction



Graph 3 Rolling Mill Change in Specific Energy Consumption



2) Surface scale (Hot billet surface iron oxide) reduction

By carrying out direct rolling (without heating), it was possible to reduce the scale.
As a result of the scale reduction, the product yield was improved, and natural resource saving could be realized.
The current actual results compared to before the introduction showed a 0.74% improvement in the yield.

3) Auxiliary materials reduction

By reducing the rolling temperature from 1,130℃ to 950℃, the mechanical qualities were improved. The auxiliary materials (ferro-alloys) used to satisfy the mechanical qualities could be reduced.
The usage amount of vanadium, the main rare metal among the auxiliary materials, was reduced. The current actual results compared to before the introduction showed a 60% reduction.

4) Amounts Saved due to the above reductions

Table 4 Amounts Saved

Item	Amount Saved
Electric Power	- ¥17 million/year
Fuel Gas	¥390 million/year
Product Yield	¥220 million/year
Auxiliary Materials	¥250 million/year
Total	¥843 million/year

3. Summary

(1) Regarding the facilities planning and construction work implementation, a project team (CAP) was established and weekly discussions were held since August 2006 concerning the progress situation and problem points. After the facilities came into operation, the planned facility performance was realized and we could succeed in attaining full production performance.

(2) Regarding the operations, in order that the effect of the introduced facilities can fully match the conditions, a project team (COP90) consisting of the on-site supervisors was created in an aim to establish a consistent steelmaking and milling management system.

As a result, a direct sending rate of 90% was realized 2 months after the start of operations, exceeding the planned direct sending rate of 70% or more. This achieved energy conservation due to the large fuel reduction and the natural resource saving due to the reduction in surface scale and auxiliary materials.

Although the effect confirmation period was 7 months, a continuous effect can be achieved.

4. Future Plans

Because a direct sending rate of 90% was achieved, the project team name was changed to COP93 with an aim of realizing a 93% direct sending rate in the future. Through maintaining and improving the facilities, and establishing a consistent steelmaking and milling management system, we aim to realize further energy conservation and natural resource saving.