KAWASAKI STEEL TECHNICAL REPORT
No.2 (March 1981)

Energy Saving Techniques of Kawasaki Steel

Shigeru Kobayashi

Synopsis :
Among some remarkable progresses made in energy saving techniques in Japan since the Oil Crisis, Kawasaki Steel has achieved more than 14% energy saving in the last five years. This noticeable result was achieved mainly by reduced energy input which itself was attained by a more efficient use of energy combined with a recovery and recycling of exhaust energy in the form of the heating of air, gas, solid materials, supported by the accumulation of some small yet significant energy-saving operational improvements and recovery of exhaust energy in the form of electric power and steam. Major energy saving techniques developed by Kawasaki relate to BF top gas pressure recovery turbine generator, coke dry quenching (CDQ), increased BOF gas energy recovery ratio, higher continuous casting ratio, a slab cooling boiler, and reduced specific-fuel consumption cost in the reheating furnace operation. At present, Kawasaki is developing heat recovery techniques, such as of sensible heat of sintered ore and BF slag. In future, a higher efficiency in energy use must be achieved in each production process as a fundamental measure for energy saving, while an inter-process energy loss will be minimized, with higher recovery ratio attained of exhaust energy.

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Shigeru KOBAYASHI **

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1 Introduction

The spiraling energy price spurred by the Oil Crisis has apparently highlighted energy saving techniques, but the steel industry was among the first to graple with the problem of energy saving long before the Oil Crisis, with its achievement in this field quite significant.

Since the start of the Oil Crisis, the energy saving efforts have been doubled based on the techniques achieved prior to the Oil Crisis. At Kawasaki Steel, energy saving as much as 14% and over has been attained in the last five years.

The following chapters will describe the performance of energy saving activities at Kawasaki, the concept and system of promoting energy saving, contents of energy saving measures and energy saving prospects for the future.

2 Energy Saving at Kawasaki

2.1 Energy Saving Ratio

Energy saving activities at Kawasaki in the last five years can be divided into two stages; the 1st for three years, and the 2nd for two years. The target of energy saving in the 1st-stage was 10%, while that in the 2nd-stage was 8%. The trend of the performance of these activities is shown in **Fig. 1.** Actual energy saving reached more than 14% in the five years, and the saving effect calculated in terms of average unit cost of purchased energy amounted to ¥87 billion in cumulative total. On the other hand, investment for energy saving equipment amounted to about ¥22 billion during the same five years. The breakdown of the performance of energy saving activities by type of energy saving measures indicates that energy saving by equipment investment was 15% and 41% for the 1st and 2nd stages, respectively, while that by improvements on operation was 85% and 59% for the same respective stages.

2.2 Oil Consumption Reducing Ratio

Energy saving activities since the Oil Crisis were primarily directed to saving oils. As a result, a great deal of oils was saved as shown in **Fig. 2,** which indicates that overall reduction in oil consumption in fiscal 1979 was 54% over 1973, the breakdown being 45% reduction in BF oil injection and 63% reduction in oils used as fuels elsewhere .Consequently, the distribution ratio of energy purchased by Kawasaki indicates, as shown in **Fig. 3,** that coal and coke account for 79%, being a greater part of the total, while oils account for 10% and purchased electric power, excluding that by generation with by-product gas,

* Received on September 9, 1980
** Technical Division

accounts for 11%.

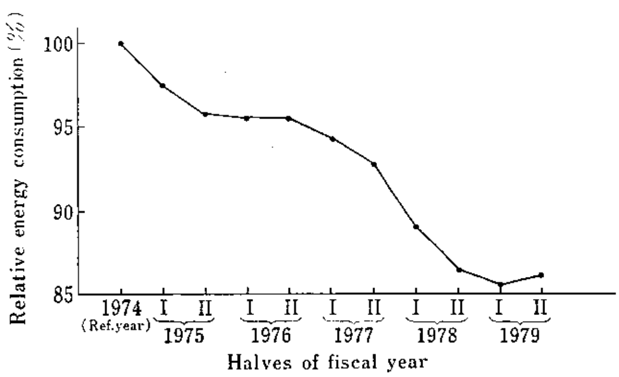


Fig. 1 Performance of energy saving at Kawasaki

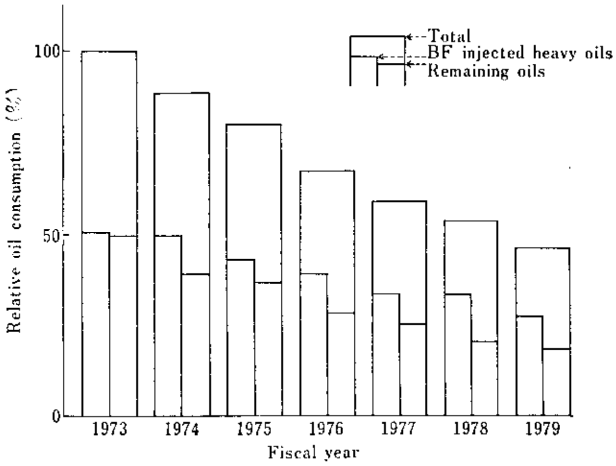


Fig. 2 Transition of oil consumption at Kawasaki

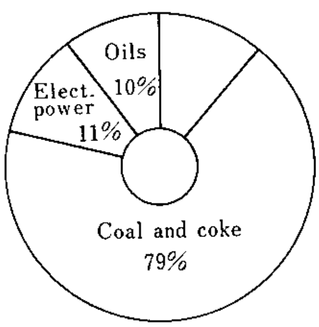


Fig. 3 Share circle of purchased energy in fiscal 1979 at Kawasaki

2.3 Major Energy Saving Measures

Energy saving measures taken by Kawasaki during the five years were diversified as shown in **Table 1.** In the first half of the five years, improvements on operation played a major role, but the room for the operational improvements gradually decreased, and in recent years the number of improvements by equipment investment has increased. Equipment-improving measures require consideration for economy of investment, but as the unit price of energy showed a steep rise, equipment-improving measures which did not pay in the past have now become economically feasible, with indication that the number of such mesaures will increase in future.

3 Energy Saving Promoting Measures at Kawasaki

3.1 Philosophy of Energy Saving

Generally speaking, energy saving activities at Kawasaki mainly consisted of drastic reduction in input energy which was enabled by efficient use of energy, and recovery and recycling of exhaust energy. In addition, surplus exhaust energy was recovered in the form of steam and electric power to realize an effective use of such energy (refer to **Table 2**). This concept is based on the idea that if priority is given to equipment investment for exhaust energy recovery in the form of steam and electric power rather than measures for input energy reduction, such initial investment may not turn out effective in the event of the quantity drop of exhaust energy resulting from in-

Table 2 Concepts of energy saving

Priority	Measure to be taken	Reduct. in input energy	Steam generation	Power generation
1	Increased efficiency in energy use	○		
2	Preheating of air, gas, and solid materials	○		
3	Power generation with surplus by-product gas			○
4	Recovery of high-temp. waste heat and waste pressure energy			○
5	Recovery of medium- and low-temp. waste heat		○	○
6	Power generation with surplus steam			○

Table 1 Energy saving measures

	Input energy reduction		Exhaust energy recovery	
	Operation techniques	Equipment techniques	Steam	Elect. power
Iron-making	· Stabilization of BF operation · Coke oven combustion control · Hot stove combustion control	· Preheating of air for combustion in hot stove	CDQ	TRT
Steel-making	· Increased recovery of BOF gas · Improvement on continuous casting ratio	· Introduction of continuous casting equipment	· Waste heat boiler for recovering BOF gas sensible heat	
Rolling	· Improvement in heat pattern of reheating furnace · Low-temp. steel materials extraction at reheating furnace · Air/fuel ratio control at various combustion furnaces · Shortening of slab track time	· Preheating of air for combustion in various combustion furnaces · Preheating of fuel gas for soaking pit · Intensification of furnace body sealing and heat insulation of various combustion furnaces · Lower air/fuel ratio combustion control at soaking pit and reheating furnace · Preheating of steel to be charged into reheating furnace · HCR and HDR · Modif. of reheating furnace into energysaving-type furnace · Heat transfer converter	· Slab cooling boiler	
Others	· Electric power saving · Steam saving	· VVVF		· In-house generating plant burning by-product gas

creased efficiency in energy use in the equipment involved, or in the case of non-use of a production equipment because of the continuation of two processes into one or the omission of one process, or in the case of a drastic drop of availability of equipment.

Energy saving is generally based on the foregoing concept, but actually, some measures have been taken as a result of reversed ranks of priority owing to other factors prevailing at the time.

As efficiency in the energy use and recovery of exhaust energy make progress, a surplus of by-product fuel and steam may occur, thereby diminishing economic incentives for further proceeding with energy saving measures. In order to avoid such an event, it is necessary to take into account at all times the energy balance of the entire steelworks so as to make plans that will give maximum effect to the entire works.

3.2 Organization for Promoting Energy Saving

The organization for promoting energy saving at Kawasaki was established in early 1974 as shown in **Fig. 4**. This figure indicates that on the basis of activities at various divisions in the steelworks, the Energy Saving Committee exercises control over the shop, and a Company-level Energy Saving Committee performs inter-shop adjustments and general control over the entire company. The activities in divisions of steelworks are supported by improvements made by "thinking groups" and by staff groups. For more important problems such as determining the orientation of the entire company, project teams are formed from time to time, and the performance of their examination is reported to the above-mentioned committee. Also some training in energy saving consciousness and energy saving education are performed by the company staff from time to time.

3.3 Target Control on Energy Saving

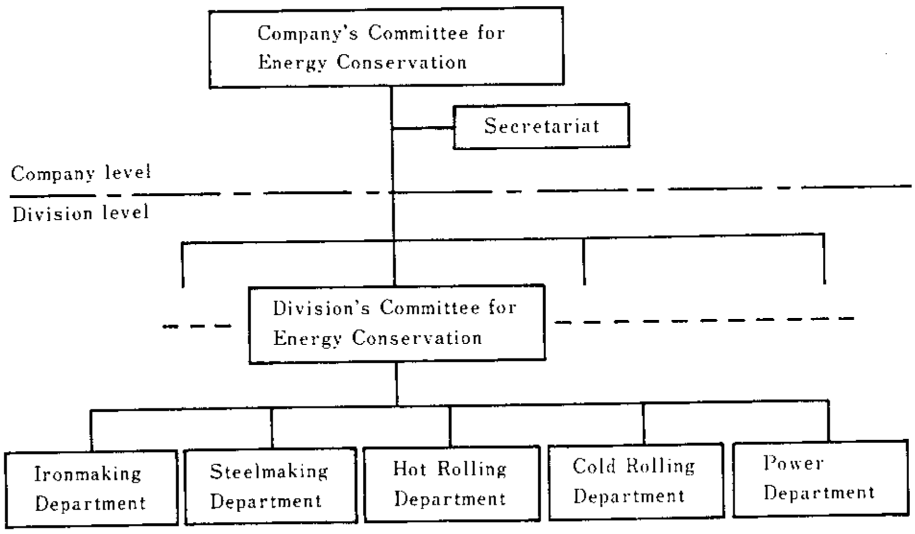
Target control on energy saving in the steelworks is performed with cooperation by energy saving staff in the steelworks to identify and develop themes in daily activities, and the results of such activities are presented to the regional energy saving deliberation meeting to be held periodically where the performance of activities are checked, and direction of energy saving activities are discussed. Then, the progress control over energy saving at the entire steelworks is carried out by the Energy Saving Committee. In this way, the target control over energy saving is promoted from the bottom to the top.

4 Major Energy Saving Techniques at Kawasaki

4.1 BF Top Gas Pressure Recovery Turbine Generator (TRT)

Along with the increasing trend of the size of the BF and its top pressure, recovery of the top gas energy has come to have a great value. Kawasaki installed for the first time in Japan a TRT of the Kawasaki Heavy Industry-SOFRAIR type at BF No. 2 of Mizushima Works in 1974. Since then TRTs were installed one by one at all the BFs (4 units) at Mizushima Works and BF No. 6 (of the U.S.S.R. type)[2] at Chiba Works; and counting one being installed at BF No. 5 at Chiba Works, seven TRTs in total with a capacity of 70 700 kW will have been installed. **Fig. 5** shows the transition of the quantity of electric power recovered

Fig. 4 Organization for promoting energy saving



by TRTs of Kawasaki. The quantity of energy recovered by this method for fiscal 1979 amounted to about 290×10^3 MWh, which accounted for about 5% of the total power consumption by Kawasaki.

The schematic diagram of the gas flow route for the GUBT (output: 12 000 kW × 2 units) of BF No. 6 of Chiba Works is shown as an example in **Fig. 6** and the specification for the GUBT is shown in **Table 3**.

The GUBT, being of the axial flow type, is sensitive to dust in the BF gas inflow, and it is necessary to prevent the wear of blades and adheasion of dust. For this reason, the quantity of dust contained in the turbine inlet gas is suppressed below the 10 mg/Nm³ level. In order to minimize trouble due to moisture contained in the gas, a BF gas heater is installed, which extracts a part (about 3%) of the turbine inlet gas for combustion and mixing, thereby heating the gas from 50°C to 120–140°C. In order to achieve this, high-pressure air is required as combustion air, and thus BF cold blast pipe is branched off to supply the heater with a high-pressure air of 140 Nm³/min per GUBT.

GUBTs, fitted with the above-mentioned equipment, are now achieving the prescribed results. At present, various kinds of TRTs are in operation including the above-mentioned Kawasaki Heavy Industry-SOFRAIR type; and with the background of increased energy saving activities, TRTs are diffused to the extent that the number of TRTs including those under construction has amounted to 31 units and an equipment capacity of 360 MW. Incidentally, the new record of recovered electric power per BF was 18 500 kW which was achieved by BF No. 6 of Chiba Works in July, 1979.

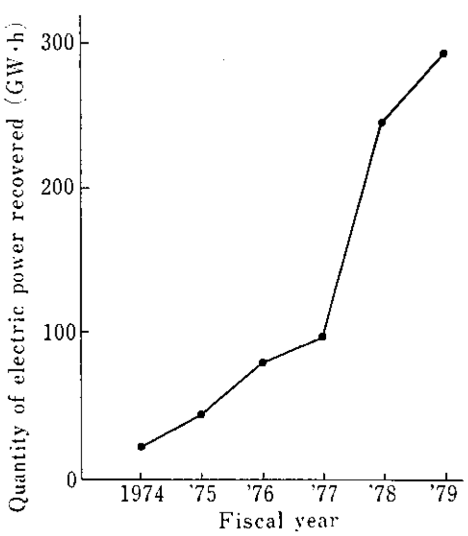


Fig. 5 Transition of quantity of electric power recovered by TRT

4.2 Coke Dry Quenching (CDQ)

The CDQ equipment of Kawasaki commenced operation at the coke oven of Chiba Works in January, 1977. This equipment is of the U.S.S.R. type and consists of 3 cooling towers each having a coke processing ability of 56 t/h. **Fig. 7** shows the general assembly and process flow sheet of the CDQ. Red-hot coke discharged from the coke oven is transported up to the top of the cooling tower and charged into the

Table 3 Specification for GUBT

Turbine		
Type		2-stage axial expansion turbine
Number of cylinder		1
Output	Capacity(kW)	12 000
	Official(kW)	10 000
Inlet gas	Flow rate(Nm^3/h)	Max.340×10^3 Nor.300×10^3
	Pressure(kg/cm^2)	Designed 2.8 Normal 2.05
	Temperature(°C)	Max.140 Nor.120
Outlet gas pressure(kg/cm^2)		0.1
Revolution(rpm)		3 000
Blast furnace gas heater		
Type		Direct mixing with combustion-gas
Gas temperature (°C)	Inlet	50
	Outlet	120~140
Generator		
Type		A.C. synchronous generator
Capacity(kVA)		15 000
Voltage(V)		10 500
Number of poles		2
Power factor		80%(lag)
Exciting method		Exciter coupled with generator rotor
Exciter		
Type		D.C. generator
Capacity(kW)		75
Step-up transformer		
Type		Oil-immersed and forced-air-cooled (domestic-produced)
Capacity(kVA)		15 000
Voltage		Primary 10 500 / Secondary 22 000

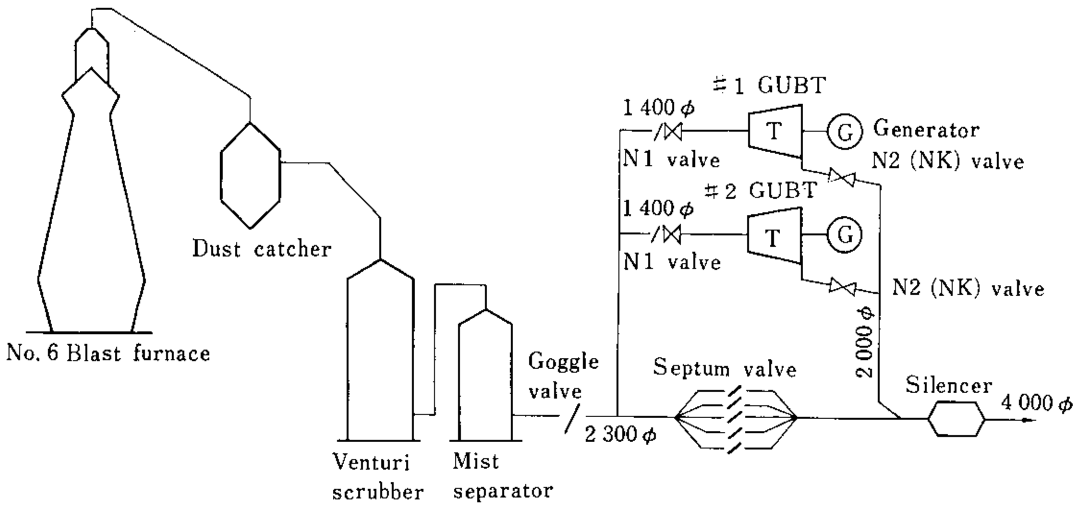


Fig. 6 Schematic gas flow route for GUBT

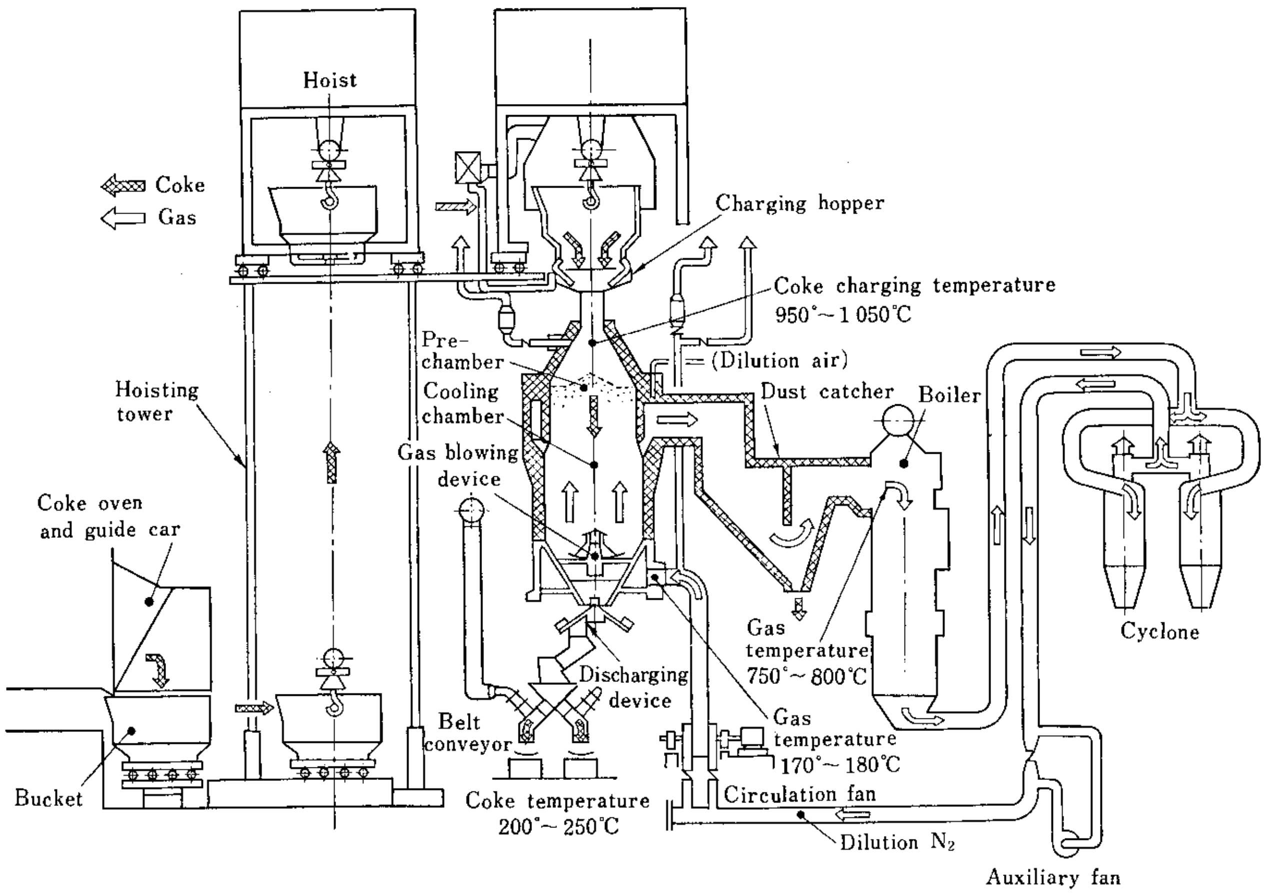


Fig. 7 General arrangement and process flow sheet for CDQ

tower. While descending inside the tower, the coke exchanges its heat with the inert gas, reaches the bottom of the cooling tower in about 2 to 3 h and is discharged at a temperature of about 200°C. The inert gas, which has thus been heated, generates steam in the boiler after having its dust removed, and is re-circulated to the cooling tower after passing through the cyclone for removal of fine dust. The steam generated is sent to the process steam piping and used as process steam for the steelworks.

The specification for the CDQ is shown in **Table 4**. Each unit of the CDQ has its own features, and one of the most outstanding of them all is the installation of pre-chamber in addition to cooling chamber in the cooling tower. Since no direct cooling by the re-circulating gas is performed in the pre-chamber, it acts as a storage chamber for red-hot coke and is expected to perform constant-quantity feeding of coke into the cooling chamber, prevention of a sudden decrease in the quantity of generated steam at the time of trouble with the coke oven operation, smoothing of the starting-up operation of the CDQ after its temporary idling, and making the temperatures of red-hot coke uniform. At the mechanical portions of the CDQ such

Table 4 Specifications for CDQ equipment

No.6 coke oven	Number of ovens	51 ovens × 2 batteries
	Dimensions	6 706 × 15 750 × 435 mm
	Prouduction ability	2 730 t/d
Cooling tower	Coke quenching ability	56 t/h × 3units
	Pre-chamber volume	120 m^3
	Cooling chamber volume	250 m^3
Boiler	Type	Single-drum water tube type
	Steam generation rate	30 t/h (at 21 kg/cm^2, 228°C)
Dust catcher	Primary unit	Baffle plate type 1 unit
	Secondary unit	Cyclone 2 units
Gas circulating fan	Main fan capacity	90 000 Nm^3/h
	Auxiliary fan capacity	35 000 Nm^3/h
Coke bucket	Volume	104 m^3
Electric locomotive	Tractive force	187t
	Speed	200 m/min
Hoist	Lifting load	82.5 t
Charging device	Type	Elcetric motor-driven link
Discharging device	Type	Hydraulically driven
Belt conveyor	Capacity	600 t/h
Dust emission control device	Type	Roto-clone N type
	Capacity	2 600 m^3/min/ × 2units

Table 5 Heat balance of CDQ

Input heat			Output heat		
Item	(10^3 kcal/t-coke)	(%)	Item	(10^3 kcal/t-coke)	(%)
Hot coke sensible heat	407.0	93.8	Cooled coke sensible heat	41.3	9.5
Supply water sensible heat	8.2	1.9	Breeze coke sensible heat	0.4	0.1
Air sensible heat	0.2	0.1	Recovered steam potential heat	365.7	84 3
Coke combustion heat	18.3	4.2	Boiler blow water sensible heat	1.6	0.4
			Waste gas sensible heat	3.1	0.7
			Surface loss	6.6	1.5
			Others	15.0	3.5
Total	433.7	100.0	Total	433.7	100.0

as transportation equipment, measures against thermal strain and dust have been fully taken up to contribute to its stable operation. As for the quantity of steam generated by the CDQ, an actual record of 520 kg/t-coke has been achieved.

Table 5 shows the heat balance of the CDQ. From this Table, it is observed that incoming heat mostly consists of the sensible heat of red-hot coke which is mostly recovered as steam. The energy recovery efficiency of the CDQ shows as high a value as 84.3%.

With the steep rise in the price of energy in recent years, various steel mills in Japan have a tendency of introducing CDQs, and Kawasaki is also constructing No. 2 CDQ equipment at Chiba Works. This equipment will drive the turbine with steam obtained by it to generate a power of 18 000 kW.

4.3 Recovery of BOF Gas Energy

Gases generated during the BOF blowing are hot and CO-rich, and recovery of their energy has been attempted since sometime ago. The method of recovery is divided into the non-combustion-type gas recovery and combustion-type steam recovery. At Kawasaki, all the BOF shops employ gas recovery, except No. 2 Steelmaking Shop at Chiba Works which employs steam recovery. Recovered gases are used as fuel at the steelworks and serve as an alternative for other purchased energy such as oils. Steam recovered at No. 2 Steelmaking Shop of Chiba Works is used as process steam in the steelworks, thereby contributing to saving in fuel for steam generation.

Of the four BOFs of gas recovery type, three shops excluding No. 1 Steelmaking Shop of Chiba Works recover as steam sensible heat of gas at the high temperature section on top of the hood. Among steelmaking shops in Japan, it was very rare to find one which accomplished such thoroughgoing exhaust heat recovery, but recently such a type of gas recovery has come to be adopted gradually in some steel mills.

No. 3 Steelmaking shop of Chiba Works (**Photo. 1**) has a Q-BOP and the recovery of both gas and steam has been made since the start of its operation. In its recent results, the quantity of gas recovery per ton of crude steel was 132.5 Nm^3 (converted at 2 000 kcal/Nm^3 and including 10×10^3 kcal/t-cs of tuyere cooling propane gas). Average calorific value of recovered gases was 2 690 kcal/Nm^3 which was a very high value for the calorific value of BOF recovered gases. The major reason for this very high recovery efficiency is that contrary to the case of the top-blown BOF, slopping rarely occurs during blowing, thus enabling the gas recovery hood to draw near to the throat in order to prevent gases from being burnt by air leakage. Recently, energy recovery has amounted to 300×10^3 kcal/t-cs (cs means crude steel) for both gas and steam, thereby achieving a significant energy saving effect.

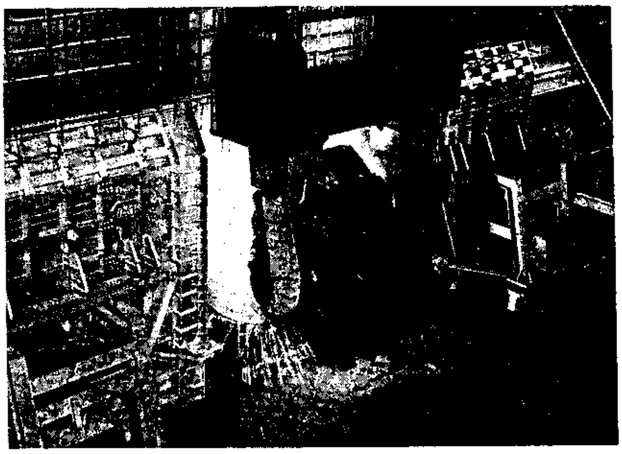


Photo. 1 Q-BOP furnace at No. 3 Steelmaking Shop of Chiba Works

The BOF gas widely fluctuates in its quantity and calorific value from time to time, and is primarily used in boilers, but a unique mixed gas distribution and combustion control system has been put into practical use at Mizushima Works to make possible large-scale use of the BOF gas in rolling mills and others. This new practice has decreased the release quantity of the BOF gas, thereby greatly contributing to reduction in the quantity of purchased energy.

4.4 Imrpovement of Continuous Casting Ratio

Continuous casting employs a continuous process covering from solidification of molten steel to the making of slabs or blooms, unlike the conventional two processes of ingot-making, and slabbing or blooming.

Mizushima Works endeavored to apply continuous casting to various types of raw materials for rolled products and as a result, has accomplished a CC ratio of more than 90% in March, 1980. At an overall company level, a CC ratio is maintained on the order of 60%. Factors for the high CC ratio are as follows: An expanded scope of application of CC steel to orders covering from high-grade to plain carbon steel in many sizes and grades; and a noticeable improvement on the continuous-continuous casting ratio by covering different types of steel in one operation and by slab width change during the casting operation. Improvements on high-speed casting techniques also have contributed to increasing the CC ratio.

The outstanding features of continuous casting lie in improvement of yield and decrease in energy consumption. The improvement of yield has been further increased by the improvement of the CC ratio and has shown about a 10% increase over the conventional process of ingot-making, and slabbing or blooming. The energy consumption by the continuous casting process has shown a decrease of about 150×10^3 kcal/t against the conventional process for killed and semi-killed steel.

The continuous casting process has recently been diffused rapidly in Japan. Kawasaki is constructing a No. 3 continuous casting equipment at Chiba Works. As a result, it is expected that the continuous casting ratio for the entire company will rise from the present 60% to the order of 80% in fiscal 1981.

4.5 Slab Cooling Boiler (SCB)

The red-hot slab after slabbing mill has a mean temperature of 1 000°C and a sensible heat of about 160×10^3 kcal/t, even after it is sheared. Previously, all this heat was dispersed into the air in order to conduct inspection to be performed before the slab is sent to the next process. In order to recover this heat in the form of steam from the slab surface by radiant heat transfer, SCB was operated for the first time in the world at the No. 2 slabbing mill of Mizushima Works in March, 1976[4]. This SCB can recover a heat of 65 to 75×10^3 kcal/t of slab. **Fig. 8** and **Table 6** show the layout of and specification for this SCB, respectively. The SCB also acts as pre-cooling equipment where part of sensible heat of red-hot slab is recovered. After being cooled there, the slab is further sent to the rotary cooler where it is cooled down to room temperature by means of immersed cooling. The steam recovered

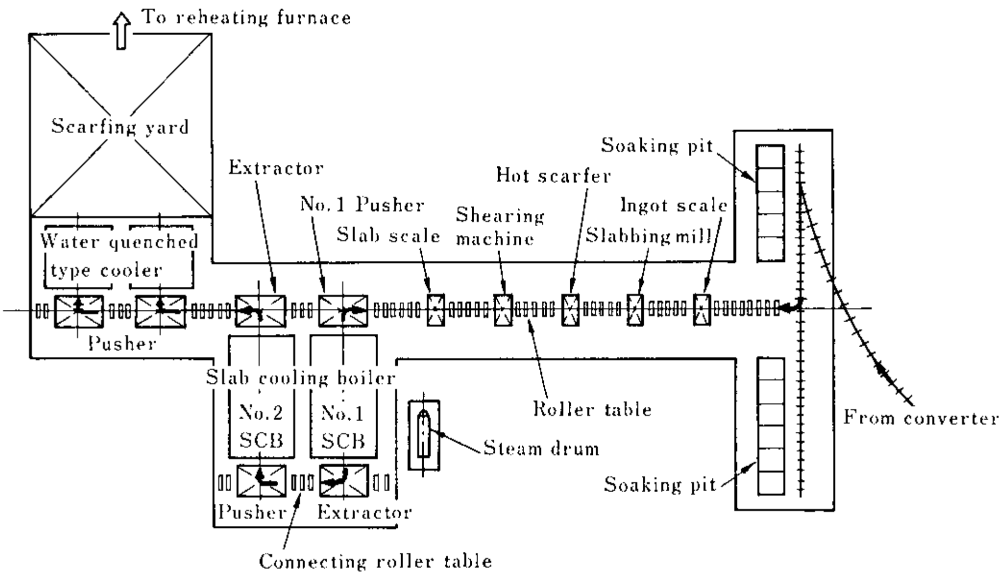


Fig. 8 Layout of SCB and slub flow

Table 6 Specification of SCB

Steam pressure	16 kg/cm²G at saturation temperature
Evaporation	Max. 70 t/h Ave. 40 t/h
Heating surface (total)	$3\,054\,m^2$ (No.1, No.2 SCB)
Boiler water circulating pumps	
–Numbers required	Two sets of motor-driven pumps (working) Two sets of turbin-driven pumps (stand-by)
–Power	150 kW
Boiler feed water pumps	
–Numbers required	One set of motor-driven pump (working) One set of turbin-driven pump (stand-by)
–Power	90 kW
Steam drum	1 700 mm$\phi\times$11 000 mmℓ

is supplied to the process steam line to contribute to saving in boiler fuel. The quantity of steam recovered accounts for about 50% of the sensible heat of the entire slab.

Since the start of its operation, the SCB has been satisfactorily working in heat recovery. Although the quantity of steam generation has decreased recently owing to the decrease in the quantity of slabbing materials as a result of a rise in the continuous casting ratio, a cumulative total of the quantity of steam recovered by the SCB since the start of its initial operation has reached 600×10^3 t.

Steelworks has many other un-used energy in the state of high-temperature solid materials, and the techniques of the SCB which effectively utilize the radiant heat transfer of solid bodies may become useful in the field.

4.6 Reduction in Specific Fuel Consumption in the Reheating Furnace

Specific fuel consumption in the reheating furnace has greatly decreased during the recent several years owing to various kinds of improvements of operation and by equipment investment (refer to **Fig. 9**).

Measures that have contributed to this reduction are as follows:

① Hot Charging for Rolling (HCR) and Hot Direct Rolling (HDR)
② Improvement on heat transfer inside the reheating furnace
③ Preheating of combustion air, fuel gases and charged steel materials by means of recovered exhaust heat
④ Measures for saving energy from the reheating furnace itself (measures such as furnace-length extension, prevention of air leakage and an intensification of furnace heat insulation)

Of the above, a few measures will be described below:

(1) The quantities of HCR and HDR at Kawasaki have been increased by the improvement in the surface properties of steel materials such as slabs and blooms. HCR is performed at a ratio of 20% in Chiba Works and at a ratio of more than 40% at Mizushima Works, while HDR is performed at a ratio of about 3% at the hot rolling operation at Chiba Works. With these measures, energy saving calculated at 15 to 30×10^3 kcal/t-product is achieved, thereby making a significant contribution to overall energy saving. Hot surface inspection and hot surface conditioning techniques also have been improved, resulting in greater improvement of steel material surface properties, with anticipation for increased quantities of HCR and HDR in the future.

(2) As a means of improving the heat transfer efficiency inside the reheating furnace, measures are taken such as low air/fuel ratio combustion, selection of the optimum heat pattern corresponding to load, and installation of the heat transfer converter which is fast applied to reheating furnace by Kawasaki. The operating principles of the converter are shown in **Fig. 10**. This unit, when heated by convection and radiation from combustion gas (Q_4) as a result of being installed inside the furnace, heats up the steel material by means of solid-body radiation (Q_6), thereby making possible

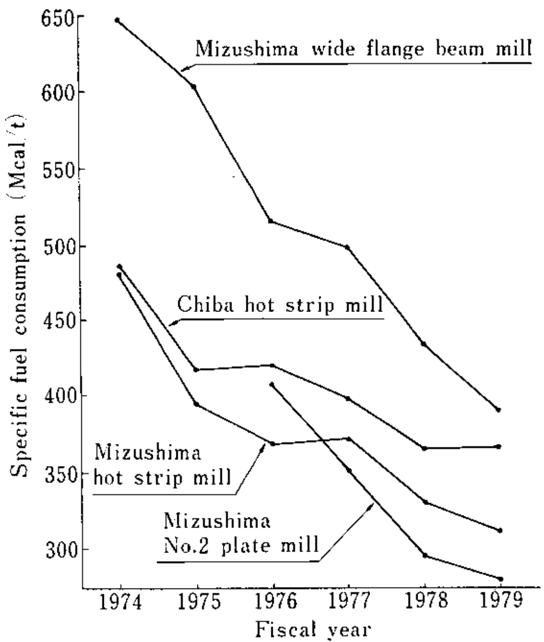


Fig. 9 Transition of specific fuel consumption in reheating furnace at Kawasaki

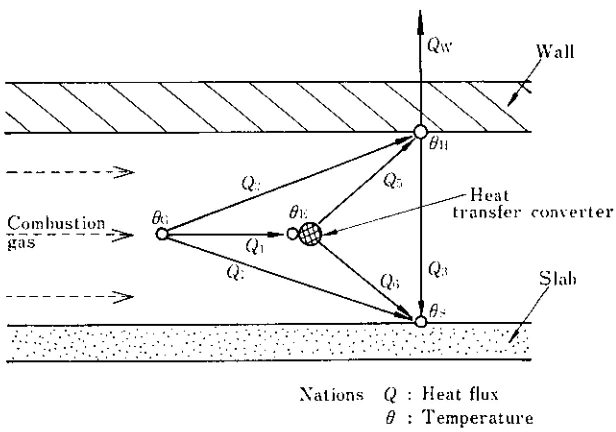


Fig. 10 Heat flow between combustion gas, "Heat transfer converter", slab and wall in reheating furnace

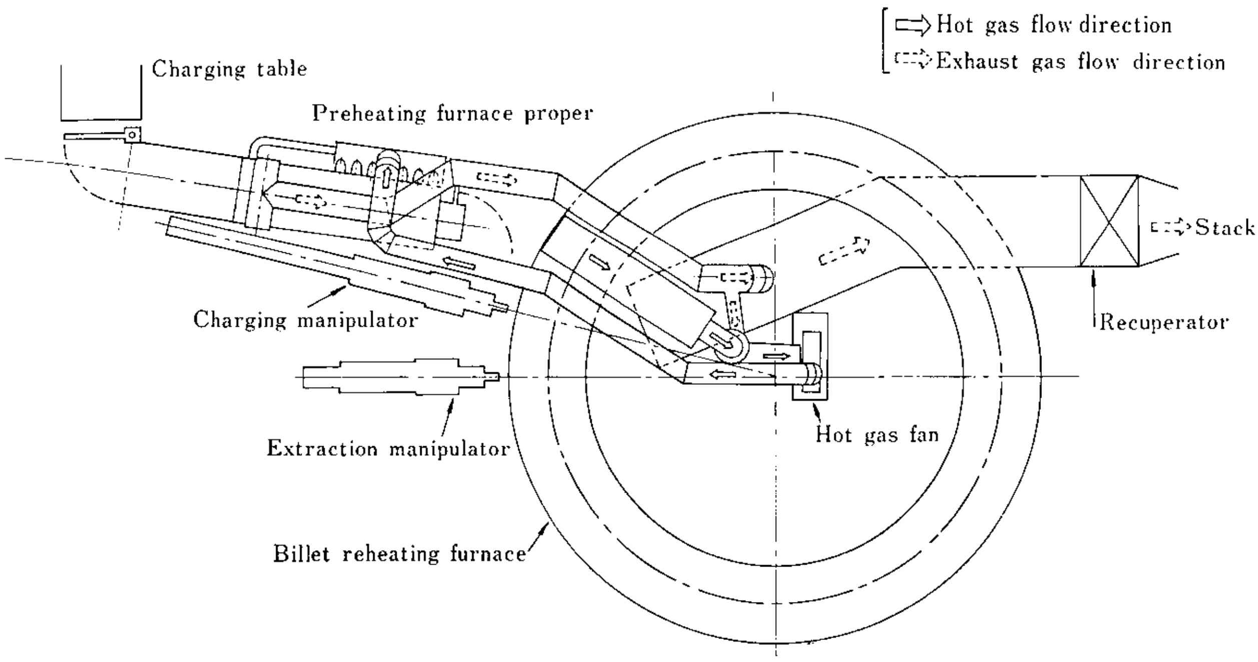


Fig. 11 Layout of jet preheating furnace for billet reheating furnace of small seamless pipe mill

effective use of sensible heat of gas. This effect brings about a reduction in specific fuel consumption of about 10×10^3 kcal/t-passing products in the actual reheating furnace.

(3) A jet preheating furnace was installed at Chita Works of Kawasaki in April, 1979 to preheat steel materials to be charged into the billet reheating furnace of small seamless pipe mill. **Fig. 11** shows the layout of the jet preheating furnace. This is a furnace in which part of exhaust gases (about 550°C) from the billet reheating furnace is blown to the surface of the billet at a rate of 80 m/s to preheat the billet up to about 300°C. This preheating furnace shows a similar effect as the HCR mentioned earlier, and brings about a considerable decrease in fuel consumption.

5 Prospect for Future Energy Saving Techniques

5.1 Efficiency Improvement of Energy Use by Advancing Existing Techniques

Energy saving activities at Kawasaki have been promoted on the basis of the primary concern for the improvement of efficiency in energy use at all times, and this concept will remain unchanged in the future. What the concept means is a decrease in input energy by minimizing the energy loss at each individual production process. In order to enhance the efficiency in energy use at each process, it would be necessary to continue efficiency-improving efforts by following up the improvements of operation and by equipment investment which have been performed to date. In concrete terms, it will be necessary to implement a thoroughgoing low air/fuel ratio combustion, selection of heat pattern best suited to changing operating conditions in the reheating furnace, raising of combustion air temperature by recovering sensible heat of exhaust gas and application of heated air to gas preheating. Further, prevention of by-product gas dispersion and further improvement in by-product recovery ratio will be necessary and possible.

5.2 Application of Energy Saving Techniques to New Objects

The iron and steel-making process is often the repetition of heating and cooling which itself is susceptible to a significant energy loss. This energy loss consists of sensible heat from products and by-products at various processes, where recovery of energy loss was mainly technically difficult and economically infeasible.

Measures conceivable for lowering the energy loss from products are 1) omission or continuation of production processes and 2) recovery and effective use of exhaust heat, and Kawasaki primarily aims at taking the former measure and intends to perform the latter measure properly depending upon ambient conditions such as manufacturing techniques. The former measure includes the following:

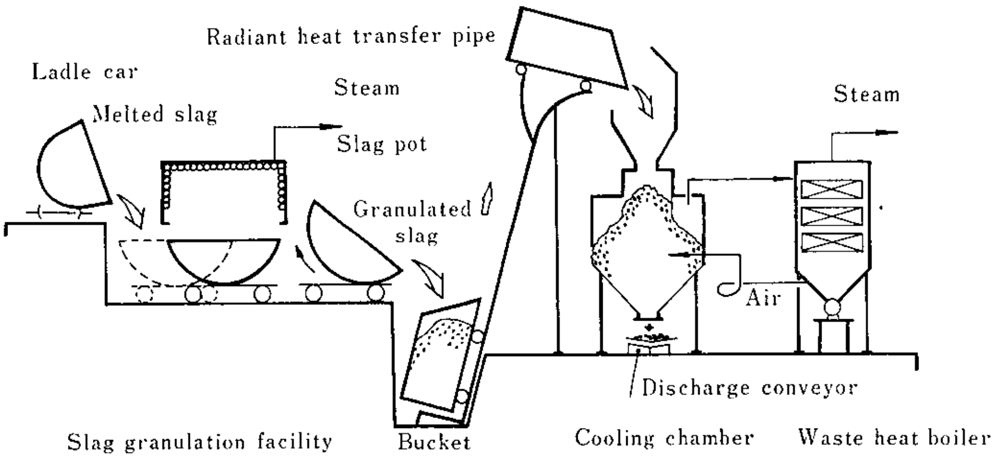


Fig. 12 General arrangement of BF slag sensible heat recovery plant

(1) Improvement in continuous casting ratio
(2) Improvement in HCR and HDR ratios
(3) Introduction of continuous annealing equipment in cold rolling
(4) Recovery of sensible heat of sintered ore
(5) Recovery of sensible heat of BF and BOF slag

All the items mentioned above are now either planned or under study. An example is the equipment now under construction at Chiba Works for recovering BF slag sensible heat in the form of steam, as shown in **Fig. 12**.

Recovery of by-product gas sensible heat has been difficult owing to a dust removal problem involved, but it is likely to become feasible by applying the dry dedusting system of BF and BOF gases. Recovery of sensible heat of the coke oven gas will be a task for development in the future.

The remaining task is the sensible heat recovery of medium- and lower-temperature exhaust gases and lower-temperature exhaust water. The efficiency of this recovery was very low and the recovery was nearly impossible in the past, but recently the prospect for this recovery has become encouraging owing to the progress in recovery techniques such as utilization of a low-temperature working medium. Kawasaki is studying in this field to achieve thoroughgoing reduction in energy loss.

5.3 Selection of Energy Use from Economic Viewpoints

The target of integrated steelworks at present is to accomplish a self-sufficient energy supply position, free from dependency upon oils and purchased electric power which itself is highly dependent upon oils. At least one measure to achieve this is to change the BF operation into an all-coke operation. This method is now put into practical use at many steelworks, and the all-coke operation will develop to a level almost equivalent to the conventional heavy oil injection operation. All-coke operation will give rise to by-product gas generation, thereby reducing the purchased quantity of oils for rolling operation. Along with the progress in energy saving, as mentioned above, by improvement of efficiency in energy use and recovery of exhaust energy, the purchased quantity of electric power will be decreased by power generation with surplus by-product gases and with exhaust heat. By going through such stages, the originally-intended target will be accomplished.

Kawasaki will endeavor to save energy in the general direction mentioned above but, in actuality, various energy saving measures, types and quantities of energy to be supplied will be determined so that the total cost of purchased energy will be minimized in both its long and short-term plans, and this basic policy will remain unchanged in the future.

6 Conclusion

Since the high rise in energy prices spurred by the Oil Crisis, reduction in oil consumption has been playing a major role in energy saving. Essentially, energy saving should be based on increasing efficiency in energy use at various processes in the iron and steelmaking, and on this basis, reduction in exhaust energy between processes or at an entire steelworks should be taken up. It is believed that steadfast execution of such measures will bring about improvement on iron and steelmaking processes and progress in energy saving techniques, thereby contributing to the development of the steel industry.

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