

● Higher Efficiency Coal Boiler Conversion Technology (Re-powering Technologies)

I. Outline of the project

The project is composed of two themes, of which the first one is “**Combustion Efficiency Upgrading**” targeting R & D by means of relatively light modification of the existing coal firing boiler in introducing an optimum operation & controlling technology in order to reduce the amount of its unburned carbon. The second target is “**Materialization of Higher efficiency Power Generation**”, which intends both effective utilization of energy resources and contribution to the amelioration of the Global Environment by establishing a high efficiency combined power generation system which uses a coal gasification system combined with an existing coal fired boiler (Coal / Coal Re-powering) .

In actual undertaking, the combustion efficiency upgrading aims at both saving of energy and reducing the ash containing unburned carbon, while the other target aims at the reduction of the carbon dioxide emission which is believed to bring us the Global Warming effect

II. Backgrounds and Outline of the R & D

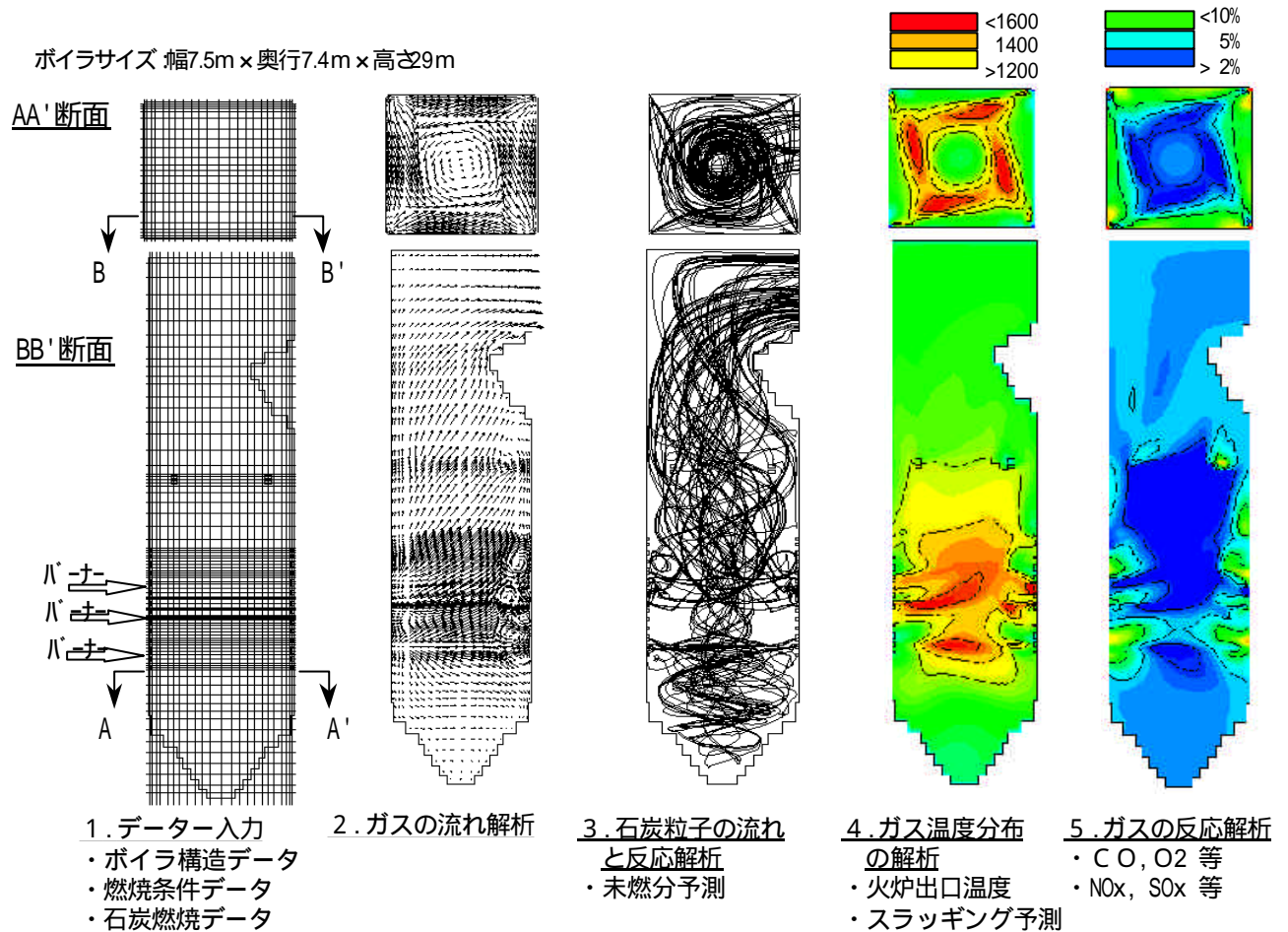
1. Combustion Efficiency Upgrading of Existing Boilers

Affected by the grand global movement of both fuel conversion from coal to natural gas and capacity enlargement of power generation units, construction of new coal firing boilers was once temporarily suspended. However, since 1975 it has been given spotlight again, and numbers of new coal firing boilers have been constructed for the uses in utilities and industries successively, and those contributing technologies for both upgrading of efficiency, as well as, of environment relating performances have been implemented year after year. In this regard, we can expect ameliorations of the coal combustibility in the use of an old boiler, which was manufactured in /around 1980, by adopting those remarkably improved technologies and the various accumulated experiences.

Those technologies related combustion ameliorations of coal firing boiler are introduced as follows,

- 1) **Heat flow analyzing technology**
- 2) **Modified burner**
- 3) **Modified mill**
- 4) **Aero furnace injection technology**

One example is introduced as follows, in which in-furnace situation of the combustion of the coal has been being reviewed,



A Sample of analysis method of Coal Firing Boiler

2. High efficiency renovation of existing boilers for power generation

In leaving the operating coal boiler as it is, by making a combination of a coal gasification furnace and a gas turbine for the first priority target to materialize the targeted high efficiency, increase of its capacity is also intended additionally. However, at present, the prevailing ones are designed to be installed with a LNG firing gas turbine which allows the existing old boilers become amended for re-powered ones to produce much more electric power. The fundamental design of the re-powering system is shown in the following table with respective configurations.

	Waste Heat Recovery	Boiler Water Preheating	Gas Turbine (GT) Addition	CCPP (**) Addition
Outline	GT+HRSG(*) Addition to existing steam turbine (ST) and <u>deletion of existing boiler</u>	GT Addition to existing boiler for preheating boiler water	GT Addition to existing boiler for utilizing its exhaust gas as air for boiler for combustion	:CPP Addition to existing boiler for utilizing
Feature	Simple system but much renovation cost	Simple system but less effect	More effect but difficulty of Operation Control	No technical risk and separated operation of GT and ST
Heat Efficiency	4 to 20% up	4 to 5% up	10% or more up	7 to 8% up
Capacity	+200%	+40%	+40%	+20 to 30%
Renovation Cost	High	Small	Medium	Medium

*:Heat Recovery Steam Generator

** :Combined Cycle Power Plant (GT+STG+HRSG)

Fundamentally, in those re-powering power generation, LNG is universally used for fuels of a gas turbine or a boiler, however, if it were replaced by oil or by coal, miscellaneous combination could be selectable. In particular, when coal is used as for gas turbine fuel, the coal gasification technology should become indispensable as a part of IGCC technology.

III. Results of the R & D

1. Upgrading of Combustion Efficiency

- (1) It has been disclosed that the expected combustion efficiency can be raised about 2.5 % (absolute value) at maximum and reduction of the unburned carbon ratio about 70% (absolute value) at maximum by introducing such ameliorating measures as the burner improvement, grain size adjusting by a mill, allocation improvement of the combustion air, etc., based on a heat flow analysis. However, in the case when the investment recovery years were limited within about 5 years such larger amendment as renewal of the mill etc. would become difficult to lead us to infer that the investing merit could remain so lower that the combustion efficiency become from 1 to 1.5%, the unburned carbon from 40 to 50%. For reference, in case of the said scale boiler, the expectable annual fuel cost reduction can be estimated from 10 to 50 million yen to meet the saved amount of coal in upgrading the combustion efficiency for 1.5 %.
- (2) By promoting the improvement of the combustion efficiency, it can be considered that the targeted value of an industrial boiler would reach 98%, and that of a general use boiler reach 95.5%. However, depending on the different performances of the related boiler and the investing circumstances, there could be naturally a large restriction on economic aspects, in which case it would be necessary for us to study on adoption of other coals with better combustibility for mixed combustion in the boiler.
- (3) By the R & D, a realistic improving countermeasure has been clearly disclosed in clarifying the improving menu on the procedures from optimum operation conditioning to minor amendment of some parts, as well as, their bringing effects and economic merits.

2. Efficiency Amendment of Power Generation by Existing Boiler

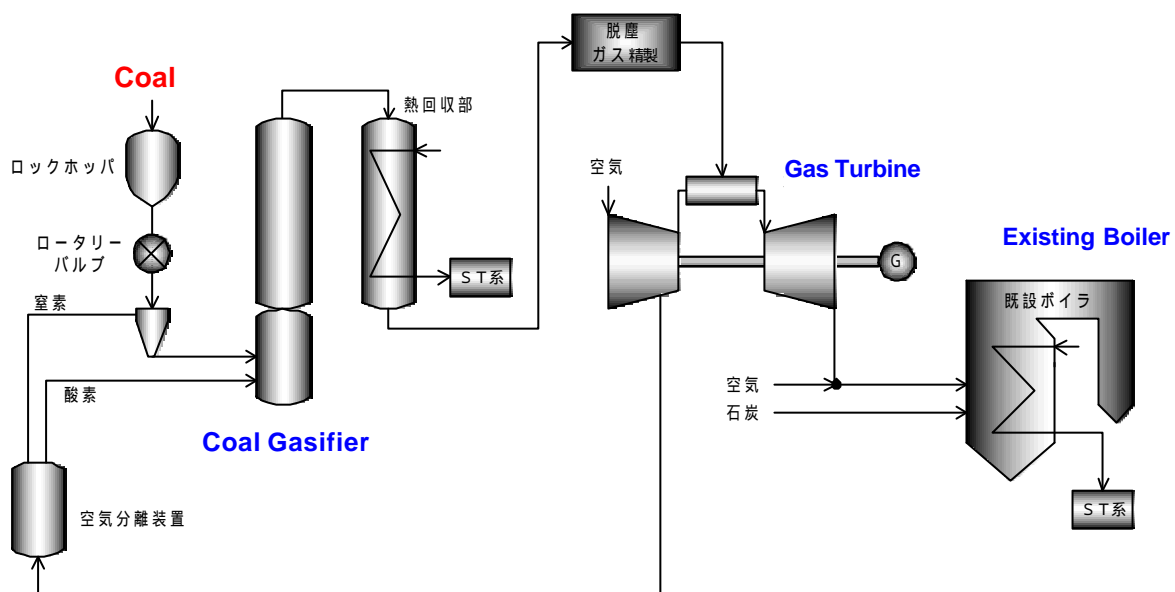
To raise the efficiency of the existing coal boiler, the following items have been reviewed.

- (1) Possibility study of a combination of the Coal gasification furnace and Gas turbine onto the Coal / Coal re-powering system.
- (2) Literature and site survey on the prevailing re-powering plants in the cases of some other re-powering system of a coal boiler which consists of a partial gas feeding machine and the Integrated Gasification Combined Cycle (IGCC) power generation as for its basal technology.
- (3) Component tests on combustibility of char in the boiler which is undertaken in re-burning the char generated in the gasification furnace by means of a combination system of a coal gasification based gas turbine and another existing coal firing boiler.
- (4) Regarding a combined system of a coal gasification furnace and an existing boiler, a series of tentative calculation was implemented on the upgrading of efficiency, reducing of carbon dioxide emission and economy of the system, etc., through a concrete reviewing in assuming those cases when such combinations are applied to two working boilers as Steam combining method, Exhaust re-burning

method and char & exhaust gas re-combusting method.

- (5) Reviewing of the merits on the additional installation of a fuel co producing plant to be attached to a gasification furnace.
- (6) Reviewing of the Re-powering effect in the case when a coal gasification power generating facility is installed to a coal-burning boiler for topping purposes.

An example of Coal by Coal re-powering system is shown in the following figure where a coal gasifier / gas turbine set is combined with an existing boiler (an exhaust gas re-burning type boiler which effectively uses the heat from a gas turbine flue gas)



The following shows some study results of those above -mentioned reviewing works,

- (1) It has been found that according to the practical working of the said two boilers, the Exhaust gas re-burning system ranks the most economic system in giving the least unit emission of CO₂, after reviewing the miscellaneous system comparisons. Regarding the Char & exhausting gas re-burning system which was assumed as a final target of the coal re-powering system in the initially planned program, it has been found that the said gasification derived char using boiler system costs much more, together with its higher emission of CO₂, and it can not be the most optimum system, owing to the fact that it requires a bigger NO₂ and O₂ manufacturing facility to cause higher installation and operating costs of the system.
- (2) Another re-powering system was also studied to reform a 100MW pulverized coal firing boiler into a 150 MW coal firing boiler by introducing either an exhaust gas re-burning system or another fuel co producing system. Each of the power generating efficiencies under respective power outputs has been

found different from each other among the three systems including a normal existing coal firing system. The two re-powering systems were found higher in their efficiency, and in the range over 115MW, it was found the highest efficiency came from the exhaust gas re-burning system. The fuel co producing system gave its uniqueness in operation in a plant where wider variations of power requirement occurred for it, because of its unique better efficiency for partial load requirement. It shows a stronger power generating capability for such bigger load variations. The capability of a gasifier differs, time to time, depending on the pattern of its load variations. If the night time load becomes one half of its day time load together with its peak load time of 8 hours a day, a fuel co producing type gasifier of a half scale in capacity can compete with a full scaled exhaust gas re-burning type boiler.

Promotion of global environment protection countermeasures could be attained in the use of those existing power plants by combining the prevailing boilers with the above-introduced various coal gasification combined cycle power generation systems, which are either under development both in Japan and overseas, or currently in demonstration stages. It will contribute much to the amelioration of overall Japanese energy system, if we could make better use of those new technologies, which would become practically usable in the near future, for the improvement of those widely disseminated existing power plants.

IV. R & D Promoting Framework

The R & D is under implementation by CCUJ with Subsidies of METI (Ministry of Economy, Trade and Industry)

[Participating Companies]

Babcock Hitach K.K.

Ebara Corporation

Hitachi Ltd.

Idemitsu Kosan Co., Ltd.

Ishikawajima Harima Heavy Industry Co., Ltd.

Kawasaki Heavy Industries, Ltd.

Mitsubishi Heavy Industries, Ltd.

The Electric Power Development Co., Ltd.

V. R & D Schedule of the Higher Efficiency Coal Boiler Introducing Technology

		FY1998	FY1999	FY2000	FY2001	FY2002 or later
Combustion Efficiency	Study	—————				
	Conclusion / FS Report			—————		
	Filed Test				▶
Power Generation Efficiency	Survey in abroad	(1) Germany (2) USA ■ ■	(3) Europe ■			
	Component Test	—————				
	Study on systemization	—————				
	Conclusion / FS Report			—————		
	Filed Test				▶