"The Completion of the Air-blown IGCC Demonstration Test and its Conversion to Commercial use”

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Executive Summary

Clean Coal Power R&D company was established to execute Air-blown IGCC demonstration testing in June 2001. The project started with 30% subsidy from METI and 70% funding from nine Japanese utility companies, Electric Power Development Company (EPDC) and Central Research Institute of Electric Power Industry (CRIEPI). After the company was established in June 2001, the first three years were spent on Environmental Impact Assessment and the design of the demonstration plant, and the next three years on construction. The demonstration test was started in September 2007.

Through the demonstration test period of five and a half years, the entire testing has progressed smoothly, although various kinds of initial incidents were experienced. Since all test items were finished successfully and the data which are necessary for a commercial plant design were obtained, the demonstration test was completed at the end of March 2013. The demonstration plant is taken over by Joban Joint Power Company and continues operation as a commercial plant after April 1, 2013. The reasons for continuing the operation are to provide critical electricity of 250,000kW during the current electricity shortage in Japan, and to obtain valuable experience and knowledge by continuing operation of the air-blown IGCC plant.

This paper shows characteristics of air-blown IGCC, summary of the demonstration test, results and evaluations of the demonstration test, and operating plans after commercial conversion of the demonstration plant.

Keywords: IGCC, air-blown IGCC, demonstration test, commercial conversion

1． Features of Air-blown IGCC

The history of coal gasification is considerably old in the field of chemical industry, and it is widely used for ammonia production, methanol production, and gasoline composition, etc. All the gasifiers for IGCCs developed in Europe and United States are oxygen-blown type, which are converted from the gasifiers for the chemical industry. In the world of the chemical industry, purity of the product gas is most important, so they are using oxygen-blown gasifiers which product gas does not include nitrogen gas as an impurity. However, when oxygen-blown type gasifiers are used in the power generation field, it requires a lot of auxiliary power for oxygen production. As a result, net thermal efficiency would considerably decrease. Therefore, although the development of Japanese IGCC was started approximately ten years later than Europe and United States, it was decided to adopt air-blown type IGCC which could obtain higher net thermal efficiency, and have been making efforts to achieve Japanese IGCC with support from the Japanese Government.

Figure_1 shows the improvement of net plant efficiency by the use of air-blown IGCC and its further improvement of IGCC net efficiency as the combustion temperature of the gas turbine becomes higher. In the field of LNG fired combined cycle power plants, many 1,500 degree C class gas turbines are already in operation. 1,600 degree C class gas turbines are under commissioning, and 1,700 degree C class gas turbine is under research and development. By applying these gas turbine technologies which have been developed in the LNG field to coal gasification IGCC, nearly 50%(at LHV base) would be realized at the commercial stage.

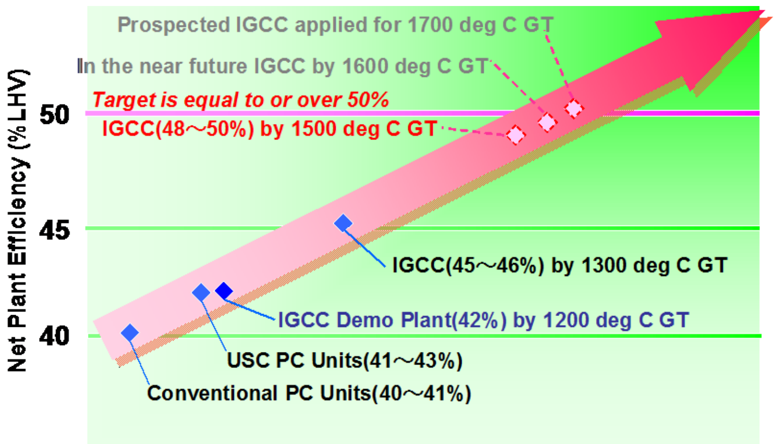

Fig._1 Thermal Efficiency Improvement of Air-blown IGCC

2． Outline of Air-blown IGCC Demonstration Tests

(1) Purpose of the Demonstration Tests

The development of air-blown IGCC started in 1983, from the process development unit test of 2t/day scale. Next stage was the pilot plant test of 200t/day scale which was carried out from 1991 to 1996 by Engineering Research Association for Integrated Coal Gasification Combined Cycle Power Systems (IGC) with 90% subsidy from the Japanese Government. The final stage of the development is this demonstration test of 1,700t/d scale. The purpose of the demonstration test is to confirm actual and practical utilization of IGCC and to acquire all data which are necessary for the design of a commercial IGCC plant. Targets were set for every item including reliability, environmental performance, thermal efficiency, fuel flexibility, economy and operability which are necessary for the commercial plant, and big efforts have been made to clear these targets. The target values for each item will be summarized later.

(2) Test Site

The demonstration test of air-blown IGCC was conducted in the premise of Nakoso Power Station, Joban Joint Power Company, in Iwaki City, Fukushima Prefecture from September 2007. Nakoso Power Station was an existing power station with a total of 4 units, 1,625MW capacity using mainly coal as fuel. This site was chosen because of the existence of infrastructure such as coal handling facilities, power transmission lines, etc. The air-blown IGCC demonstration plant is known as the “Nakoso IGCC" from the name of the place.

(3) Specifications and Features of the Demonstration Plant

Table_1 shows the specifications, Figure_2 shows the schematic diagram, and Figure_3 shows the bird’s-eye view of the Demonstration Plant.

Table_1 Specification of Nakoso IGCC Demonstration Plant

Capacity	**250 MW gross**		
Coal Consumption	**approx. 1,700 metric t/day**		
System	**Gasifier**	**Air-blown & Dry Feed**	
	Gas Treatment	**Wet (MDEA) + Gypsum Recovery**	
	Gas Turbine	**1200 deg C-class (50Hz)**	
Efficiency (Target Values)	**Gross**	**48% (LHV)**	**46% (HHV)**
	Net	**42% (LHV) ***	**40.5% (HHV)**
Flue Gas Properties (Target Values)	**SOx**	**8 ppm**	**($16\%O_2$ basis)**
	NOx	**5 ppm**	
	Particulate	**4 mg/m^3N**	

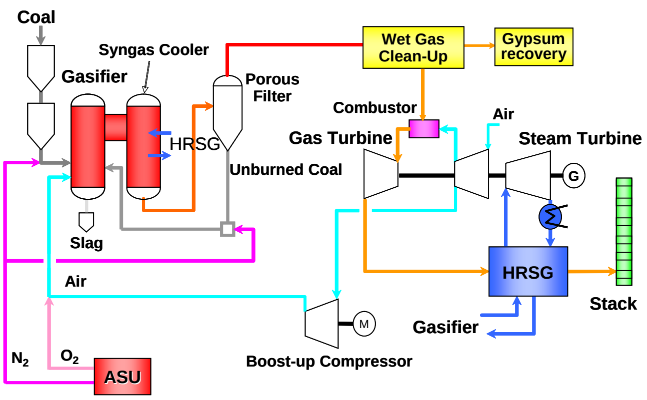

Fig._2 Schematic Diagram of Air-blown IGCC Demonstration Plant

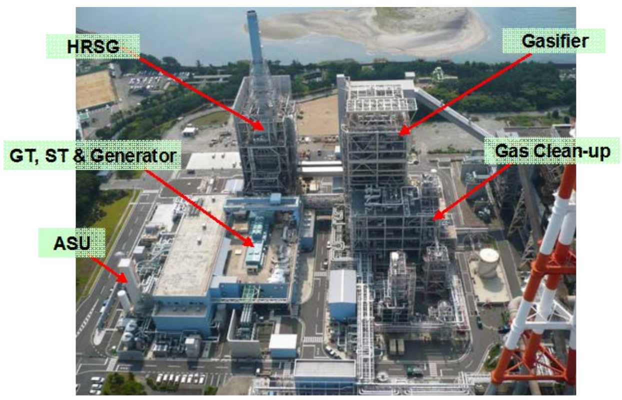

Fig._3 Bird’s-eye View of the Demonstration Plant

The capacity of the demonstration plant was sized to be 250MW, which is half the size of a commercial plant. This resulted in the use of gas turbine with combustion temperature of 1,200 degree C class and a target net efficiency of 42% (LHV base). However, in the commercial stage, net efficiency of an IGCC plant would be 48% - 50% by adopting the 1,400 - 1,500 degree C class gas turbine.

The features of each facility are summarized below.

a. Features of the gasifier

・ Adoption of two-staged entrained flow configuration

The gasifier is required to satisfy two functions. First is to maintain calorific value of the syngas which ensures stable combustion at the gas turbine, and second is to discharge coal ash smoothly as molten slag from the gasifier. It is necessary to maintain the temperature inside the gasifier high enough to achieve these functions. However in the case of air-blown single stage gasification, it is difficult to maintain the temperature high because a large quantity of nitrogen exists in the air and it is harder to raise the temperature in the gasifier compared to oxygen-blown IGCC. Therefore, the technological difficulty of air-blown IGCC is much higher than that of oxygen-blown IGCC. To overcome this challenge, the two-staged entrained flow type gasifier in which the gasifier is divided into a combustor and a reductor was adopted.

・ Adoption of dry coal feeding, nitrogen pressurization, and high-density transportation system

The pressure of the gasifier is high at about 3MPa, and pulverized coal is required to be injected into this high pressure atmosphere. For safety reason, nitrogen is used to pressurize pulverized coal, and a high-density transportation system is used for decreasing the injection volume of nitrogen to the gasifier. Although cryogenic type ASU (air separation unit) is installed to produce nitrogen, its capacity is very small compared to oxygen-blown IGCC. In addition, co-produced oxygen is utilized as gasifying agent together with the gasification air.

・ Adoption of Self coating system

The temperature inside the combustor in the gasifier is extremely high at about 1,800 degree C, so that coal ash melts and flows down. However, refractory material is not used. Membrane waterwall is protected from high temperature radiation by adopting a self-coating system in which the wall is covered with melting ash (slag) itself in centrifugal flow.

・ Adoption of Char recycling system

Coal is partially combusted in the gasifier, therefore syngas contains char which is a mixture of unburned carbon and fly ash. The char is collected by porous filters and is recycled back to the gasifier. Hereby, more than 99.9% of carbon in coal can be gasified, and concentration of unburned carbon in molten ash discharged from the bottom of the gasifier is less than 0.1%.

・ Monitoring of slag flow

It is important that the slag is discharged stably from the bottom of the combustor in order to maintain stable operation of the gasifier. Therefore, real-time video camera monitoring of slag flow is always available in the main control room. Furthermore, an audio monitoring system is also installed as a back-up in case the image monitoring system fails.

b. Features of Gas clean-up facility

Wet gas cleanup system using chemical solvent is adopted in this plant. Impurities such as hydrogen sulfide H2S, carbonyl sulfide COS, ammonia NH3 and hydrogen chloride HCl are included in raw syngas from gasifier. Ammonia NH3 and hydrogen chloride HCl are removed by scrubbing with water. Carbonyl sulfide COS is converted into H2S by a COS convertor, then hydrogen sulfide H2S is removed using an amine solution. As these impurities are removed up-stream of gas turbine, the gas turbine is protected from these impurities and emission of these components into the atmosphere can be avoided. In addition, the eliminated hydrogen sulfide H2S is recovered as gypsum which is sold as by-product.

c. Features of Combined cycle facility

There are many LNG fired combined cycle power plants already in operation together with abundant actual experience. Calorific value of syngas is approximately one tenth of that of LNG at about 13,000kcal/kg, and the type of gas turbine combustor is different, while the remaining portions of the gas turbine other than the combustor are basically the same. Although the calorific value of syngas is relatively low, there is no difficulty for using it as gas turbine fuel from a pure combustion point of view. A diffusion type combustor with a simpler configuration can be applied, because thermal NOx caused by syngas combustion is lower than that from LNG.

d. System Integration

IGCC is mainly comprised of the gasifier, gas clean-up facility and combined cycle facility. Net efficiency of IGCC is greatly dependent on the overall plant configuration, especially concerning gasification agent (air) and steam integration. At Nakoso IGCC,

- Extracted air from the air compressor of the gas turbine is used as gasification agent after boosting up it to necessary pressure for the operation pressure of the gasifier.
- Steam generated at the syngas cooler of the gasifier is introduced to steam turbine together with those generated from heat recovery steam generator downstream of the gas turbine.
- Part of high temperature gas turbine exhaust gas is extracted from the heat recovery steam generator and used as heat source for coal drying.

By applying these integrations, Nakoso IGCC achieves high net efficiency.

３． Results and evaluation of the demonstration test

Table_2 shows the actual schedule of the IGCC demonstration test that was carried out for five and a half years. Table_3 shows targets and results from the IGCC demonstration test.

Table_2 Actual Schedule of the IGCC Demonstration Test

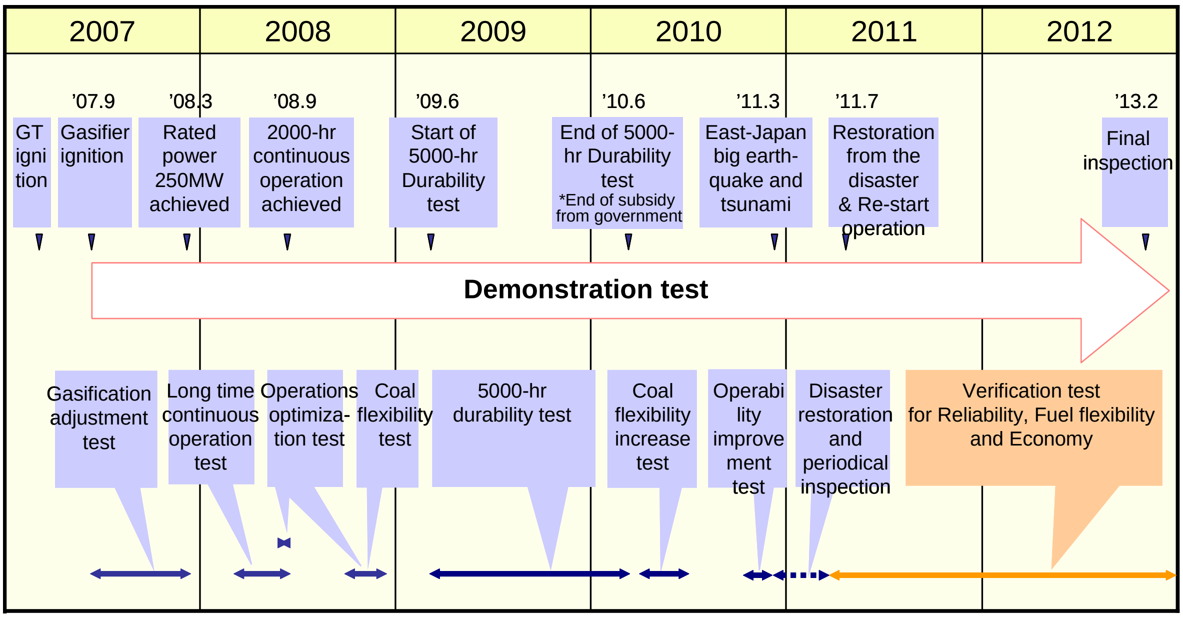

Table_3 Targets and Results from the IGCC Demonstration Test

items	targets	results
System Safety and Stability	Safe and stable operation to be verified during start-up, operation and shutdown	Stable operation at rated power 250MW and safe shutdown were confirmed（2008/3）
Environmental Performance	Emission concentrations at outlet of stack SOx：8ppm NOx：5ppm Dust：4mg/m3N	Emission concentrations less than target values were confirmed（2008/3） SOx：1.0ppm NOx：3.4ppm Dust：0.1mg/m3N
Reliability	2000-hr continuous operation (equivalent to 3 summer months)	2039-hr continuous operation (2008/9)，and 2238-hr continuous operation(2011/11) was achieved.
Fuel Flexibility	Operations using multiple coal types other than the designed coal (Chinese coal)	North American PRB sub-bituminous coal（2009/2），Indonesian sub-bituminous coal（2009/3、2010/9），Colombian coal(2011/10),Russia coal（2011/12），Indonesiancoal(2012/1),North American Signal Peak sub-bituminous coal（2012/10）
Thermal Efficiency	Net thermal efficiency 42% (LHV)	Net thermal efficiency of 42.9%(LHV) was achieved. (2009/1)
Durability	Durability of components and auxiliaries to be examined by inspection after 5000-hr operation	・Total of 5000-hr operation/ year was accomplished. ・No fatal damage of equipments were found by the overhaul inspections following the 5000-hr operation. ・Large earthquakes, measuring lower 6 on the Japanese intensity scale of 7, caused no serious damage to main equipments. This verified their high earthquake resistance.
Economy	Evaluation of economy of commercial IGCC by the results of construcion, operation and maintenance of Demonstration Plant	There is a possibility that power generation cost of IGCC will be equivalent to that of pulverized coal fired power generation.
Operability	Operability required as thermal power plant	Operability equal to conventional thermal power plant was confirmed (2011/3) （startup time 15-hrs、minimum load 36%、 load change rate 3%／min etc.）

The IGCC demonstration test was started with the ignition of the gasifier in September 2007. Rated output of 250MW was achieved in March 2008, a half year after the test started, 2,000 hours continuous operation was achieved in September 2008, one year later, and 5,000 hours durability test was carried out from June 2009 to June 2010. At this point, all the test items and targets set forth by the government had been finished and satisfied. Therefore, government subsidy was terminated in June 2010. Thereafter the demonstration test was continued under the support from nine Japanese electric utility companies, Electric Power Development Company (EPDC) and Central Research Institute of Electric Power Industry (CRIEPI) to improve its reliability, fuel flexibility, and economy.

(1) Evaluation of thermal efficiency

The target net efficiency was 42% (LHV base), with performance test results at 42.4-42.9% well satisfying the target value. Table_4 shows the results of the performance test that was conducted a half year after the test started.

(2) Evaluation of Environmental performance

As for atmosphere environmental emission performance, target concentrations at the outlet of the stack were 8ppm for SOx, 5ppm for NOx, and 4mg/m3N for Dust. These target values were cleared at rated load during the performance test in March 2008, as shown in Table_4. In addition, the targets for other environmental characteristics such as the quality of waste water, noise levels, and vibration levels were all cleared.

Table_4 Results of Plant Performance Test in March 2008

	Design values	**Results**
Atmospheric Temperature	15 degC	13.1 degC
Gross Output	250 MW	250.0 MW
Gas Turbine Output	128.9 MW	124.4 MW
Steam Turbine Output	121.1 MW	125.8 MW
Net Efficiency (LHV)	42 %	42.4 %
Cold Gas Efficiency of Gasifier	73 %	75.3 %
Carbon Conversion Rate	>99.9 %	>99.9 %
Syngas LHV	4.8 MJ/m^3N	5.2 MJ/m^3N
Composition CO	28.0 %	30.5 %
CO_2	3.8 %	2.8 %
H_2	10.4 %	10.5 %
CH_4	0.3 %	0.7 %
N_2 & Others	57.5 %	55.5%
Environmental Performance	<Target values>	
(16% O_2 Corrected) SOx	8 ppm	1.0ppm
NOx	5 ppm	3.4 ppm
Particulate	4 mg/m^3N	<0.1 mg/m^3N

(3) Evaluation of reliability

Because electric demand is high during summertime in Japan, 2,000 hours continuous operation which is equivalent to three months of summertime operation was set as the target of reliability. Continuous operation of 2,039 hours was achieved one year after demonstration test started.

Continuous operation of 2,238 hours was achieved in November 2011 after suffering the East Japan great earthquake and tsunami disaster. This is so far the longest continuous operation duration at the demonstration plant. Since there are no major limiting factors for continuous operation, continuous operation record is expected to be prolonged in the future.

(4) Evaluation of Durability

Target for durability test was set that any serious damage can not be found at each facility during overhaul inspection after 5,000 hours durability test which started in June 2009. During this test, initial incidents occurred, and sometimes it led to plant shutdown. However, accumulative operation hours reached to 5,000 hours in June 2010 just one year after starting the durability test. As a result of subsequent overhaul inspections, no serious damage was found at each facility. Hence, durability of the demonstration plant was confirmed. Contents of the initial incidents will be described later.

Furthermore, the East Japan great earthquake and tsunami disaster hit the demonstration plant on March 11, 2011. The facilities were shaken by the earthquake with a seismic intensity of six, the entire facility was flooded by 1.3-2.0 meters of seawater due to the tsunami that followed the earthquake and suffered serious damage. The plant was shut down automatically and safely, triggered by the detection of high vibration at the turbine. By hard work of employees and suppliers, the plant was able to be restored in such a short period of about 4 months. Although there was huge damage to the plant, these facts provided unexpected proof of the plant's durability against an earthquake and tsunami.

(5) Evaluation of Operability

It is normally assumed that IGCC will be used for base load operation because it is a coal-fired power plant, but assuming middle load operation in the future, the target of operability was set to be the same as operability of a conventional thermal power plant. Test results of the operability showed start-up time of 15 hours from cold start, minimum load of 36% and load change rate of 3%/min. etc., which are about the same as the operability of conventional thermal power plants.

(6) Evaluation of Fuel flexibility

Design coal of the IGCC demonstration plant is Chinese Shenhua coal. Stable operation using Shenhua coal was confirmed as expected. After that, fuel flexibility tests using a total of 9 different kinds of coal, such as sub-bituminous coal from the United States and Indonesia, and bituminous coal from Indonesia, Colombia, Russia and Canada were carried out.

Coals that have low fuel ratio and low ash melting temperature are suited for the IGCC. These are different from coals suited for conventional coal-fired plants. Figure_4 shows this feature. Low fuel ratio means having higher volatile matter content and easier to gasify, and this kind of coal includes sub-bituminous coal which is younger and having low level carbonization. In addition, the reason why coals having low ash melting temperature are suited for IGCC is to melt coal ash in the gasifier and to discharge the molten ash from the gasifier. This is a different concept from coals suitable for conventional coal-fired power plants.

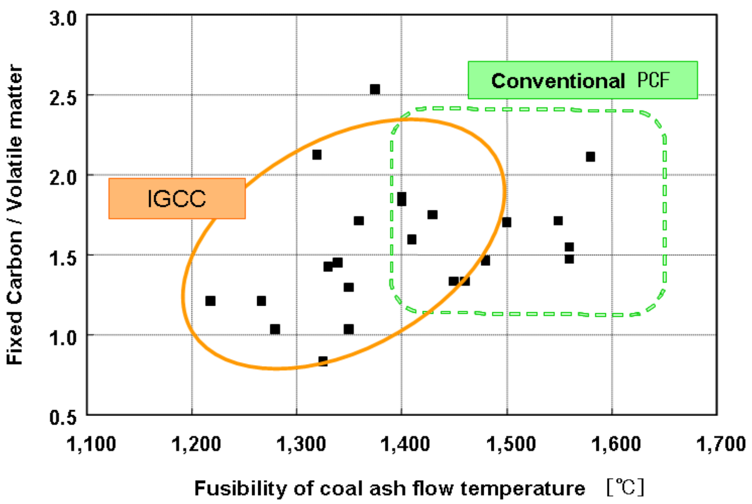

Fig._4 Coal for Pulverized Coal Firing and Coal for IGCC

Coals used for the demonstration test were selected mainly from coals suited for IGCC. It was verified during the tests that all of these coals can be used for gasification. Various phenomena were observed when the coal was changed, and it became clear that application of various adjustments and changes in operation were necessary for stable operation. The findings are summarized below.

・ Countermeasures for using sub-bituminous coal (High moisture coal)

Gasification of sub-bituminous coal was very good, but some limitations were noticed. These included limitation of coal drying capability at the coal pulverizer because of its high moisture content, as well as capacity limitation at one of the auxiliary equipment in the gas cleanup facility because of slight composition change in syngas, and capacity limitation at the waste water treatment facility due to increase of waste water. Therefore, the operation load of the plant was restricted to 60-80% when sub-bituminous coal was used.

These limitations when using sub-bituminous coals occurred because the demonstration plant is designed for Chinese Shenhua coal (bituminous coal). Operation of a commercial IGCC plant using 100% sub-bituminous coal at rated load will be possible, if the plant is designed appropriately by reflecting various test results obtained during the demonstration test.

- Countermeasures for using high ash melting temperature coals

For IGCC, coals with lower ash melting temperatures are easier to use, because ash is melted in the gasifier and discharged as slag. Because ash fusion temperature of the design coal was less than about 1,400 degree C, coal blend operation was needed for the demonstration plant, when using high ash melting temperature coals.

In the commercial stage, installing flux addition equipment is another option to use coals with high ash melting temperatures to achieve rated load operation. Ash melting temperature can be lowered by adding a flux (calcium such as limestone etc.), and the effectiveness of flux was examined at the pilot plant test.

- Countermeasures for plugging at the Syngas-cooler

SGC heat exchanger (syngas cooler) is installed at the outlet of the gasifier, where steam is generated by absorbing the heat from syngas of around 1,100 degree C. Char has a tendency to deposit on the heat exchanger tubes at the inlet in the SGC, and this char has possibility to cause plugging problems by sintering when this char is left more than a certain time. Therefore, high pressure soot blowing systems were installed in the SGC in order to remove char periodically.

As a result of the demonstration test, it became clear that sintering of char happens in a relatively short time depending on the kind of coal used, and has tendency to plug at the inlet area of the SGC. This can be avoided by adopting configurations to minimize char accumulation at the SGC inlet area and by increasing the blowing frequency of the high pressure soot blowing system. Various coals would be able to be used at the IGCC commercial plant by designing properly.

(7) Utilization of coal ash

In an IGCC plant, coal ash becomes molten slag in the gasifier, then broken into small pieces by quenching with cold water and is discharged in the form of a glassy slag. In the demonstration plant, slag was recycled 100% as cement raw materials and roadbed materials.

In addition, it has been confirmed that the slag can be used for asphalt paving material and aggregate of concrete during the demonstration test. When the slag volume increases in the commercial stage, it can be widely used for such purposes. However, for further expansion of slag utilization, standardization of the slag utilization will be needed.

The volume of slag discharged from a commercial IGCC plant will be half compared to the volume of fly ash from a conventional coal fired power plant. This is because the volume of coal ash decreases by melting and the quantity of coal ash itself decreases due to improved thermal efficiency by 20%. Furthermore, leeching of trace elements does not occur because IGCC slag is glassy, which is another environmental superiority

(8) Items to be reflected on design of commercial plant based on results of the demonstration test

a. Reflection of items encountered during initial operation

The initial problems occurred mostly during 5,000 hours durability operation test for one year from June 2009. Table_5 shows the problems occurred at that time. The initial problems occurred mainly in auxiliary facilities, not in the main facilities such as the gasifier, gas cleanup facility and combined cycle facility as is shown in the table.

Table_5 Major Initial Problems during Durability Test

Item of Incident	System	Root Cause	Cure
1.Leakage from Gland packing of Rotary Valve below Porous Filter	Char Recycle System	Inadequate tightening of a packing caused the gas leakage from the ground.	Proper control of tightening the packing at the ground
2.Trip of Slag Discharge Conveyor	Slag Treatment System	Scraper of the drag chain conveyor meandered and stuck onto the gutter of the bottom plate, and caused overloading of the conveyor motor.	Improvement of the conveyor structure
3.Leakage of Coal from the Pulverized Coal Collector	Pulverized Coal Supply System	Filter cloth tore and pulverized coal accumulated in the bag filter was oxidized and increased in temperature.	Monitoring device added and operation procedure improved
4.Leakage of No.2 Extraction Air Cooler Tube	Gasifier Air Supply System	Inadequate and irregular tube material selection caused corrosion. Air leaked to the condenser and resolved oxygen concentration in condensate water increased.	Tube material correctly changed
5.Leakage of Char Gasifier Burner Cooling Tube	Gasifier	Inadequate positioning of the burner front edge caused erosion of the burner cooling tube	Proper control of positioning the burner front edge

To verify the validity of the countermeasures, operation test was continued for 2 years after the durability test. No further issues were noticed on these areas during 2-year extension operation, therefore, the validity of measures were confirmed.

b. Selection of materials for syngas piping

High temperature sulfidation corrosion by hydrogen sulfide H2S in raw syngas was severe in the piping from the outlet of the SGC heat exchanger to the gas cleanup facility. At the demonstration plant, low alloy steel was adopted as the piping material by accepting corrosion to certain amount. Although the corrosion speed was almost as same as expected, generated rust accumulated in gas cleanup facilities afterward or block up the strainer at the gas turbine inlet. This caused some operation limitations or some plant shutdowns. In the commercial stage, this problem will be solved by adopting stainless steel-based materials for high temperature syngas piping.

c. Measures for erosion of syngas piping

Char (mixture of unburned carbon and fly ash) is contained in raw syngas which flows through the syngas piping. Because char has erosion characteristics, a few areas experienced erosion such as at the base of thermowell and at pipe bends. The pipe bends already used erosion-resistant material, however, the area applied was insufficient and resulted in erosion. Based on these experiences, appropriate erosion measures will be taken in the commercial plant.

d. Plant design depending on the coal used

As stated above, when high moisture coal will be used in the commercial plant, consideration such as larger drying capacity at the pulverizer, appropriate capacity design for both gas cleanup facility and waste water treatment facility are needed. As for the plugging at the SGC inlet, countermeasures such as appropriate tube arrangements and appropriate blowing frequency of high pressure soot blowing system will be taken to prevent plugging by char sintering for operation using various kinds of coal.

e. Simplification of the facilities

A roller crusher for crushing lumps of the slag at the gasifier slag discharge system, and de-slaggers for cleaning the reductor inner wall were installed at the demonstration plant. Since stable operation was possible even when these equipments were not used, these equipment may not be necessary in the commercial plant.

In addition, it became clear that appropriate tube arrangement in the SGC is not only effective to reduce char deposit, but also effective to making the SGC more compact. In the commercial plant, plans to make the facilities more compact and reduce cost are now being studied by applying these measures.

４． Operation plans after conversion of the demonstration plant to commercial use

As mentioned in the beginning of this paper, the IGCC demonstration test was finished at the end of March 2013 and, after April 1, 2013. Joban Joint Power Company takes over the demonstration plant and continues its operation as a commercial plant. The purpose of this take over is to utilize the 250MW demonstration plant as power supply, and to let the IGCC technology become more mature by continuing the operation. The way to transfer and future operation plans are as follows.

・ Transfer to Joban Joint Power Company

Clean Coal Power R&D Company was merged to Joban Joint Power Company and became extinct, and Joban Joint Power Company took over the IGCC facility as a surviving company and performs commercial operation as Unit No.10 of Joban Joint Power Company. Some personnel moved from Clean Coal Power R&D Company to Joban Joint Power Company to perform operation and maintenance of the IGCC facility for the time being.

・ Operation plan after conversion to commercial use

During demonstration operation, electricity generated at the IGCC demonstration plant was transmitted to Tokyo Electric Power Company. This remains the same after commercial conversion. The demonstration plant was originally a research facility, which was not designed for sufficient service life and with few backup facilities. Ease of maintenance is not considered much either. Therefore, although the facility is somewhat hard to be used for commercial operation for these reasons, it is planned to utilize this facility as a commercial base load unit for about 10 years by making improvements on these points.

Conclusion

Clean Coal Power R&D Company is very happy to realize the commercial conversion of the demonstration plant. The development of air-blown IGCC was carried out for about 30 years with the support of the government under phased scale-up. The first was the 2t/d process development unit that began in 1983, next was the 200t/d pilot plant test that began in 1991, and the last was this 1700t/d demonstration plant. Careful scale-up is a big reason why the demonstration test could be finished in success.

I would like to express my gratitude to all utility members who were seriously engaged in this project as well as the distinguished engineers of Mitsubishi Heavy Industries, and the local people for their contribution and understanding of this project.

Conversion of the demonstration plant to commercial use is to be highly pleased, however, this is just the beginning of the commercial air-blown IGCC. Our final target is the construction of true commercial IGCC plants which adopt 1,400-1,500 degree C class gas turbine and have nearly 50% net efficiency. Hereby, we can contribute to "saving of coal resources" and "prevention of global warming" that was our original purpose of the project. Because there are a lot of old and low-efficiency coal-fired power plants still in operation in the world, adaptation of air-blown IGCC to replace these old power plants will significantly contribute to "prevention of global warming".

With completion of the demonstration test, it is now technically possible to construct a commercial air-blown IGCC at anytime. However, the highest hurdle for deciding on the construction of the IGCC commercial plant at this time seems to be economics. I believe "Construction cost of air-blown IGCC is about 20% higher than that of conventional coal-fired plants because facilities are more complicated, but fuel cost of air-blown IGCC is about 20% lower than that of conventional coal-fired plants because the net thermal efficiency is about 20% higher. Therefore, electric generation cost of air-blown IGCC is about the same as that of conventional coal-fired plant". Unfortunately, higher initial cost is becoming a higher hurdle for electric power companies or IPPs, even if the long-term electric generation cost is the same level. In this situation, we are now studying various measures to reduce the construction cost together with Mitsubishi Heavy Industries who is the IGCC manufacturer, so that the construction costs of IGCC will be close to construction costs of conventional coal-fired power plants as much as possible.

I think it is desirable that IGCC plants and conventional coal fired plants should coexist, and it is not preferable to construct all coal-fired plants using IGCC only in the future. Coexistence of both plants leads to wider choice of coal types in the world, because coals suited for IGCC and coals suited for conventional coal-fired plants are different.

After the accident at Fukushima No.1 nuclear power plant due to the East Japan great earthquake disaster of March 11, 2011 in Japan, operation of nuclear power plants has become difficult resulting in the shortage of power source for base load in Japan. Under such situation, the needs for the IGCC, which can use abundant coal with low CO_2 emissions, is increasing. I look forward to the construction of the first commercial air-blown IGCC using this unique and original Japanese technology in the near future.