2A3. Internal Circulating Fluidized-bed Combustion Technology (ICFBC)

Research and development: Japan Coal Energy Center; Ebara Corporation; Idemitsu Kosan Co., Ltd.
Project type: Coal Production and Utilization Technology Promotion Grant
Period: 1987-1993

Technology Overview

1. Features

The basic characteristics of ICFBC are described below:

I. Uniform temperature in fluidized-bed, owing to the swirling flow of sand.

II. Easy discharge of non-combustibles, also owing to vigorous movement of sand.

III. Ability to control the temperature of the fluidized-bed by adjusting the heat recovery from the fluidized-bed.

Based on these, ICFBC has the following features:

1) Adoption of various fuels

Similar to CFBC, ICFBC is capable of using not only fossil fuels, such as high-grade coal, oil, and gas, but also low-grade coal, biomass, sludge, waste plastics, and waste tires.

2) Control of bed temperature

Since the overall heat transfer coefficient varies almost linearly with the variations in the air-flow rate in the heat recovery chamber, the quantity of recovered heat is easily regulated through the control of the air-flow rate. In addition, control of the quantity of recovered heat regulates the temperature of the fluidized-bed. Since the control of the recovered heat is performed solely by varying the air-flow rate, adjusting the load is very simple, which is a strong point of ICFBC.

3) Low polluting

NOx and SOx emissions are significantly decreased without special environmental modifications. For the fluidized-bed boiler, desulfurization takes place mainly in the furnace. However, ICFBC does not have a heat transfer tube in the fluidizing section, so the boiler does not cause wear on the heat transfer tube in the bed. Because of this, silica sand can be used as the fluidizing material for ICFBC, instead of soft limestone. As a result, ICFBC needs minimum quantities of limestone as an intrafurnace desulfurization agent. The desulfurization efficiency of ICFBC approaches 90% at a Ca/S molar ratio of around two, though the efficiency depends on the coal grade, the amount of limestone applied, and the temperature of the fluidized bed. Denitration is conducted through a two-stage combustion process: the reducing combustion at the fluidized-bed section, and the oxidizing combustion at the freeboard section. The unburned carbon from the boiler is collected by the high-temperature cyclone installed at the exit of the boiler. The collected, unburned carbon is recycled to the boiler to increase the denitration efficiency.

4) Space-saving, ease of maintenance

Similar to CFBC facilities, ICFBC facilities do not need separate units for desulfurization, denitration, and fine-fuel crushing. Therefore, ICFBC facilities are space saving and easier to maintain because trouble-spots are minimized.

2. Technology overview

Figure 1 shows an overview of ICFBC. The technology uses silica sand as the fluidizing material. The fluidized-bed is divided into the main combustion chamber and the heat recovery chamber by a tilted partition to create a swirling flow inside the main combustion chamber and a circulation flow between the main combustion chamber and the heat recovery chamber. A circulation flow is created to return the unburned char and unreacted limestone from the cyclone at the exit of the boiler to the boiler.

1) The swirling flow in the main combustion chamber is created by dividing the window box in the main combustion chamber into three sections, and by forming a weak fluidized-bed (moving bed) at the center section, introducing a small amount of air while forming strong fluidized-beds at both end-sections and introducing large volumes of air. As a result, the center section of the main combustion chamber forms a slow downward moving bed, and the fluidizing material, which is vigorously blown up from both ends, settles at the center section, and then ascends at both end-sections, thereby creating the swirling flow.

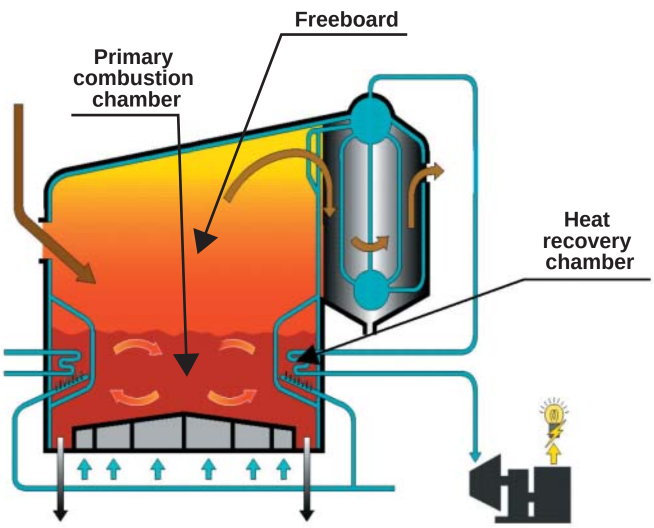

Fig. 1 Overview of ICFBC

2) The circulation flow between the main combustion chamber and the heat recovery chamber is created by the movement described hereafter: A portion of the fluidizing material, which is vigorously blown up at both end-sections in the main combustion chamber, turns the flow direction toward the heat recovery chamber at a position above the tilted partition. The heat recovery chamber forms a weak fluidized-bed (downward moving bed) through the circulation bed air injected from under the chamber. Accordingly, the fluidizing material circulates from the main combustion chamber to the heat recovery chamber, and again to the main combustion chamber from the lower part of the heat recovery chamber. Since the heat recovery chamber is equipped with heat transfer tubes, the circulation flow recovers the thermal energy in the main combustion chamber.

3) The circulation flow from the cyclone at the exit of the boiler passes through the cyclone or other means to collect unburned char, emitted fluidizing material and unreacted limestone, and then returns to the main combustion chamber or the heat recovery chamber, using a screw conveyer, pneumatic conveyer, or other means. The circulation flow is extremely effective in increasing the combustion efficiency, decreasing the generation of NOx, and improving the desulfurization efficiency.

Photo 1 ICFBC site

3. Study sites and application fields

Examples of locations and companies using coal-fired ICFBC include: Chingtao, EBARA CORP. (10 t/hr); Jiangsan in China (35 t/hr); and Nakoso, Nippon Paper Industries Co. (104 t/hr). Examples of locations and companies using ICFBC using industrial waste as the fuel include: Motomachi, Toyota Motor Corp. (70 t/hr); Tochigi, Bridgestone Corp. (27 t/hr); Fuji, Daishowa Paper Mfg. Co., Ltd. (62 t/hr); Amaki, Bridgestone Corp. (7.2 t/hr); and Akita, Tohoku Paper Mfg. Co., Ltd. (61.6 t/hr). In Shizuoka, Chugai Pharmaceutical Co., Ltd. is operating an RDF-fueled ICFBC site (3.7 t/hr).

4. Development period

ICFBC was developed in 1987, and was further developed and validated as a low-polluting, small-scale, and high-efficiency fluidized-bed boiler for multiple coal grades in the "Study of Fluidized-bed Combustion Technology," conducted by the Coal Utilization Technology Promotion Grant project of the Ministry of International Trade and Industry over the course of six years from 1988 to 1993.

5. Progress and development results

Although ICFBC was initially developed to use high calorific value industrial waste, it was improved to use solid fuel with a high calorific value and has been developed as a coal-fired boiler. A boiler plant was constructed in China, a country with abundant coal reserves, in the city of Chingtao, a manufacturing base. Recently in Japan, wood-based biomass has been used as a fuel in some cases. However, a further reduction in up-front investment costs is required to disseminate the technology to Southeast Asia and other areas rich in biomass resources and low-grade coal.

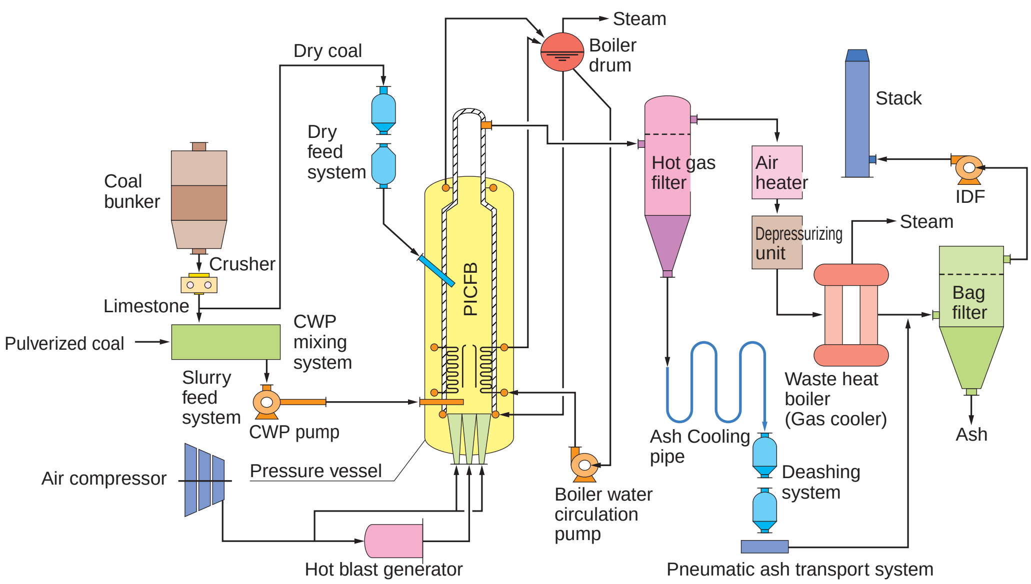

Fig. 2 Flowchart of PICFBC model test plant