Research and Development on PFBC-CC in China and Jiawang Pilot Plant Project

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Pressurized Fluidized Bed Combustion (PFBC) is recognized as an advanced coal-fired technology which can improve efficiency in combined cycle scheme and reduce environmental pollution. Progressive status on PFBC-CC in China is presented in this paper. Test results on a 1 MWt bench scale experimental PFBC facility is reviewed briefly. Based on retrofitting of an old steam power plant located at Jiawang, a project to construct a PFBC-CC pilot plant is under way. Designed capacity of the pilot plant is about 15 MWe, 3 MWe from gas cycle and 12 MWe from steam cycle. The system configuration, main design parameters, estimated technical performance as well as construction schedule of the pilot plant are described. The bright future for PFBC-CC in China is also indicated.

Keywords: pressurized fluidized bed, combustion, combined cycle, pilot plant.

INTRODUCTION

Coal is the main energy resource in China. More than 70% electric power is generated by coal-fired power plants in our country. It will be continued to be dominant even through next century. The need for new electric generating capacity is growing along with the growth of Chinese economy. Meanwhile, environmental pollution caused by coal combustion is concerned with by Chinese people. So, searching new technologies to burn coal cleanly and efficiently to produce electricity is a very important task of Chinese energy experts. Pressurized Fluidized Bed Combustion (PFBC) is just one of the Clean Coal Technologies (CCT). Advantages of PFBC are recognized as follows: Its combustion efficiency can be as high as 99%. SO₂ emission is reduced through inherent sulfur capture with sorbent such as limestone or dolomite added in combustor, without a special chemical sulfur removal facility. Low bed temperature (1073-1173 K) also produces low NOₓ emission. Pressurized combustion results in compact combustor, convenient to manufacture, transport and erect. Thus, capital cost is reduced. Energy in hot, pressurized gas can be recovered through the use of gas turbine. Combined gas-steam cycle makes efficiency improvement in PFBC-CC power generation. It is suitable to retrofit or/and repower old steam power plants as well as be applied for new installed base-load power generation.

Studies on PFBC-CC in China were begun in early 1980's by Southeast University (SEU, former Nanjing Institute of Technology, NIT). Under the support of Chinese State Scientific and Technological Commission, a 1 MWt experimental bench scale facility (SEU PFBC) was installed in 1984 at Thermal Energy Engineering Research Institute of Southeast University. The test facility has performed successfully, with more than 700 accumulative hours long time tests to the end of 1992. In view of that progress, Chinese State Planning Commission has decided to construct a PFBC-CC pilot plant to accelerate commercialization of PFBC technology in 1991. As one project of the 8th "five-year" plan of China, a 15 MWe PFBC-CC pilot plant is being built, which is located at the Jiawang Power Plant in Xuzhou City of Jiangsu Province. Its design and construction are under way. Southeast University is still the principal institution for the R & D of the project, in cooperation with more than twenty institutions, including the Jiawang Power Plant of Jiangsu Electric Power Bureau, and Harbin Boiler Works, etc. It is scheduled that commissioning
tests of the whole plant will be started in 1995, and it will make preparation for a 150 MWe scale commercial demonstration PFBC–CC power plant in next step.

**EXPERIMENTAL SCALE R & D FOR PFBC**

The system of the 1 MWt SEU PFBC test facility is shown in Fig. 1.

![Fig. 1 1 MWt SEU PFBC test facility system](image)

1. coal hopper  
2. sorbent hopper  
3. impeller coal feeder  
4. impeller sorbent feeder  
5. coal injector  
6. sorbent injector  
7. transportation air compressor  
8. combustion air compressor  
9. PFB combustor  
10. ash removal valve  
11. ash lockhopper  
12. primary cyclone  
13. secondary cyclone  
14. tertiary cyclone  
15. flowmeter  
16. primary cyclone ash hopper  
17. secondary cyclone ash hopper  
18. tertiary cyclone ash hopper  
19. ash pushcart  
20. cascade  
21. silencer  
22. cloth filter  
23. spare coal hopper

The PFB combustor is encapsulated with a pressure vessel of 1.8 m diameter and height of 7.62 m. The cross-section area of the inner combustor is 0.184 m² and the height is 5.5 m.

The coal and sorbent (dolomite or limestone) particles, being screened and dried, are fed into the bottom of the PFB combustor by means of rotatory feeders and pneumatic jets. Combustion air comes from compressors. Flue gas produced in PFBC passes through three stages of gas cleanup cyclones, enters the blade cascade test section, Venturi tube for reducing temperature, exhaust silencer, finally exhausts to atmosphere.

Experimental tests at the SEU PFBC facility have been successful: Some necessary data and experience were obtained for the design and development of the 15 MWe PFBC–CC pilot plant. Test results over 700 hours show that the operation of the SEU PFBC test facility was stable. Two key techniques, coal feeding and ash discharging, were solved successfully. The combustion efficiency for high ash coal (ash content as high as 57%) was 95–98%, and the highest one has been 99%. The sulfur retention efficiencies were above 85% at the Ca/S molar ratio between 1.53 and 1.70 in many tests. The emissions of SO₂ and NOₓ during tests have met environmental protection standard. Flue gas was cleaned up quite enough after passing through three stages of cyclones, the dust concentration in the flue gas was less than 200 mg/Nm³ and fineness not greater than 10 μm at outlet of the tertiary cyclone.

**PILOT SCALE R & D FOR PFBC–CC**

After successful R & D at the SEU PFBC test facility over ten years, a project to construct a pilot scale power plant for further R & D of PFBC–CC was decided by Chinese government in 1991.

Retrofitting of an existing old power plant with