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RETROFITTING 25T/h PULVERIZED COAL-FIRED BOILER INTO 35T/h CIRCULATING FLUIDIZED BED BOILER FOR BURNING MIXTURE OF COAL AND BAGASSE

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Abstract

In China, there are a large number of pulverized coal-fired industrial boilers, whose steam capacities are usually relatively small. These boilers can burn only high-grade coal and have low combustion efficiency. Furthermore, the combustion emissions, such as SO_2 and NOx, pollute the environment severely. Therefore it is very important and urgent to adopt economically efficient and environmentally friendly technologies to retrofit these boilers.

At the same time, there are many industrial wastes, such as bagasse, wood waste, rubbish, petroleum coke and so on, need burning disposal in China. Fluidized bed combustion technology is a kind of clear combustion technology, which has many advantages, such as excellence fuel flexibility, high combustion efficiency, low pollutant emission and good turndown capability etc. So, adopting fluidized bed combustion technology, retrofitting pulverized coal-fired boiler into fluidized bed boiler can realize pure burning various wastes or co-firing with coal, which should have great economic benefits and social benefits. And the application prospect of the method is also extensive.

The State Key Laboratory of Coal Combustion has successfully retrofitted a 25t/h pulverized coal-fired boiler into circulating fluidized bed boiler with in-bed tubes and downward exhaust cyclone. The retrofitted boiler can burn mixture of coal and bagasse and the steam capacity reaches 35t/h. This paper presents the retrofitting measures and the operation status of the boiler after retrofitting.

INTRODUCTION

In China, there are over 500,000 industrial boilers to generate steam for various production requirements. Most of these boilers burn coal and the steam capacity is relatively small, typically ranging from 25t/h to 35t/h. Usually these boilers have bad adaptability to coal and low combustion efficiency. And they have no SO_2 and NOx emission control facilities. As a result, the pollutant emissions can't reach the national standard. Moreover, after running for a long time, these boilers no longer meet the request for expanding production capacity and the operating cost increases because the coal price goes up and the combustion efficiency goes down. Considering above, retrofitting these boiler is necessary and profitable.

In recent years, circulating fluidized bed (CFB) boilers have been developed rapidly in China. CFB combustion technology has proved to be an effective means for utilizing low-grade fuel and reducing SO_2 and NOx emissions over conventional coal combustion technologies without having to use expansive pollutant control equipment. CFB boilers have the ability to handle fuels as diverse as agricultural waste, municipal solid waste, wood wastes, industrial and municipal sludges, plastic, tires and coal, which are especially suited to the fuels with low heat value and high moisture characteristics. The CFB unit is viewed as an attractive, competitive option to retrofitting pulverized coal-fired (PC) boilers.

The State Key Laboratory of Coal Combustion (SKLCC) has successfully developed and commercialized a distinctive Π-shaped CFB boiler which adopts a novel cyclone separator with downward exhaust gas. The novel separator can conveniently replace the gas reversal chamber of a PC boiler and maintain the boiler in its Π-shaped configuration. It is compact, low cost and reliable, and it is economically competitive with other technologies for retrofitting.

Using the SKLCC's CFB combustion technology, a 25t/h PC boiler was successfully retrofitted into a 35t/h CFB boiler to burn the mixture of coal and bagasse.

25T/h PC BOILER

There was a 25t/h PC boiler in Lutang Sugar Refinery, Guangxi Province. The boiler had two steam drums and the convective tube bank was mounted transversely. The superheaters were mounted between the screen tubes and the convective tube bank. The economizer and the air preheater were mounted in the backpath. The boiler parameters are showed in Table 1.

The boiler generates steam for electricity and heat supply. The steam demand kept increasing with the expanding of the sugar-refinery's production capacity. However, the original steam capacity of the boiler couldn't meet the need.

The boiler had to burn high-grade coal and couldn't utilize bagasse, a byproduct of sugar-refinery. Because the thermal efficiency of the boiler was low, the coal consumption was great. In order to reduce the operating cost, the sugar refinery urgently required to retrofit the boiler to burn mixture of coal and bagasse.

Through studying and comparing, the CFB boiler with downward exhaust cyclone was adopted.

Table 1 Design Parameters of the 25t/h PC Boiler

Item	Unit	Value
Steam Capacity	t/h	25
Steam Temperature	^{o}C	400
Steam Pressure	MPa	2.45

RETROFITTING MEASURES

The retrofitted CFB boiler would burn mixture of bituminite and bagasse. The main parameters of the fuel are shown in Table 2. The steam capacity of the boiler is enlarged to 35t/h, and the steam temperature and the steam pressure remain.

Table 2 Fuel Parameters

Item	Unit	Bituminite	Bagasse
Mix Percent	%	60	40
LHV	kJ/kg	16747	13655
Moisture	%	15.18	48

The 35t/h CFB boiler is schematically shown in Fig. 1.

The following measures are taken:

(1) The combustion chamber consists the upper dense phase bed and the low dilute phase bed. There are 16 groups of in-bed tubes placed in the dense phase bed, and each group includes 3 tubes. The total area of the in-bed tubes is 29.6m^2.

(2) The V-type ash hopper was replaced by air plenum and air distributor located below the combustion chamber.

(3) The height of the steam drum was heightened 1 m and the front wall of the boiler was moved forward 1.05m in order to enlarge furnace capacity and reduce fluidized velocity and prolong residence time of fine particle in the combustion chamber, and improve combustion effect.

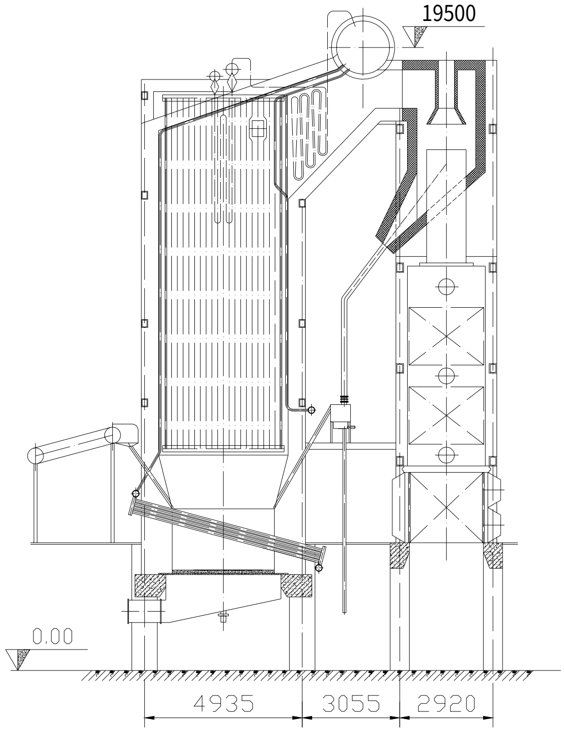

Fig. 1 Sketch of the 35t/h CFB Boiler

(4) Two cyclone separators with downward exhaust gas are installed on the upper of the backpath, where the backpath connects with the horizontal flue gas path. The fly ash in the circulating burning system is separated by the downward exhaust gas cyclone separators. The fly ash collected by the separators is returned to the combustion chamber via the loopseal for circulating combustion for the purpose of increasing combustion efficiency.

(5) The fluoseal is adopted. Because it can be adjusted automatically, there is no need to change the aeration with the load change.

(6) The lower steam drum and the convective tube bank were removed, and single steam drum mounted transversely is adopted.

(7) In order to reduce the velocity of flue gas and abrasion, and to lay out enough heat transfer area of the economizer, the front posts of the backpath were moved 400mm towards furnace. Meantime the back posts of the backpath were moved towards both sides until the width is the same as the width of the steel work of furnace.

(8) The high temperature superheater and the low temperature superheater are arranged separately. The high temperature superheater is on the top of the furnace, while the low temperature superheater is in the entrance of the horizontal flue gas path.

(9) The heat transfer area of the economizer is increased, and the heat transfer area of the air preheater is decreased. The detail is showed in Table 3.

(10) Antiwear measures:

a. The in-bed tubes are 7mm thick, and wearable fins were welded on the windward side of the in-bed tubes in certain angle.

b. The walls, 2m above the air distributor, are built with sillimanite refractory brick

c. The bent tubes of the economizer are embedded in the wall, and wear shield and homogeneous flow distributor were installed on the windward side of front several rows tubes of the economizer.

d. On the windward side of the front several rows tubes and the leeward side of the back several rows tubes and the bent tubes of the low temperature superheater, wear shields are installed.

(11) The changes of the areas of various heat transfer surfaces before retrofitting and after retrofitting are shown in Table 3.

Table 3 Areas of Heat Transfer Surfaces

Heat transfer surfaces	Area after retrofitting (m^2) (35t/h)	Area before retrofitting (m^2) (25t/h)
In-bed tubes	29.6	0
Water-cooled walls	119.7	131.2
High temperature superheater	45.0	48.8
Low temperature superheater	112.2	125.8
Economizer	738.7	368.1
Air preheater	690.9	725.5

(12) Replace the low-pressure fan with the high-pressure blower.

(13) Coal is fed by belt feeder. Bagasse is pneumatically fed, and the feeding position is 5.8m high on the front wall.

CFB BOILER OPERATION

The boiler is designed to combust mixture of 60% bituminite and 40% bagasse. The unit price of the coal is 300 yuan per ton (about 35 US dollars per ton) and the heat value is 16747kJ/kg. The unit price of the bagasse is 70 yuan per ton (about 8.5 US dollars per ton) and the heat value is 13655kJ/kg. Apparently, it is economical to combust mixture of coal and bagasse considering from the price proportion of coal and bagasse.

After the boiler was put into operation, the various operation conditions are experimentally studied, the results follow:

(1) Burning mixture of 60% bituminite and 40% bagasse

The coal is conveyed by the lower belt feeder and then fallen into the combustion chamber through the feeding tubes. The bagasse is conveyed by the upper belt feeder and then pneumatically fed into dilute phase zone. The coal burns mainly in dense phase zone and the bagasse burns mainly in dilute phase zone. The steam capacity of the boiler can reach 30 ~ 32 t/h. The bed temperature is 930 ~ 980 ^{o}C and the exit temperature of the furnace is 680 ~720 ^{o}C. The steam parameters reach the normal values, and the boiler can be stably operated.

(2) Burning bagasse alone

The ash content of bagasse is much lower, so fluvial sand (diameter 1 ~ 2 mm) is used as bed material when utilizing bagasse alone. The bagasse is conveyed by the upper belt feeder to the front wall and fed into the combustion chamber by pneumatic conveying through the feeding inlet at the height of 5.8m. The combustion mainly occurs at the top part of the combustion chamber. The exit temperature of the furnace is about 800 ^{o}C and the bed temperature is merely 180 ~ 200 ^{o}C. The steam capacity can reach 26t/h to 28t/h, and the steam parameters also reach normal values. The steam can be used to drive steam turbine generator for electric power.

(3) Burning coal alone

The coal is fed into the combustion chamber by the belt feeder. When the coal burns alone, the steam capacity only can reach about 22t/h. The bed temperature is 960 ^{o}C. The exit temperature of the furnace is about 400 ^{o}C. The steam parameters can't reach normal values, and the steam only can be used to supply heat, or to drive a low parameter (1500kW) steam turbine generator for electric power.

PROBLEMS WHEN BOILER OPERATING

As a whole, the retrofitting is successful. The retrofitted boiler has reached the design target and good economic performance has been achieved. But there are still two problems needing to be solved.

(1) When bagasse burns alone, bagasse is fed from upper part of the combustion chamber, so bagasse burns mainly in the dilute phase zone. As a result, the temperature of dense phase zone is only 180 ~ 200 ^{o}C and the steam capacity of the boiler decreases. The potential measure to solve the problem is to feed bagasse from the bottom, and then bagasse can burn both in the dense phase zone and in the dilute phase zone.

(2) The transition from combusting coal alone to combusting mixture of coal and bagasse or to combusting bagasse alone is easy. But in reverse, the transition from combusting bagasse alone to combusting coal alone or to combusting mixture of coal and bagassse is difficult. It is needed to fire the start-up burner again for the bed re-ignition. The process will take so long time as to affect steam supply. To change the existing feeding mode of bagasse i.e. to use bottom feeding, may solve the problem.

CONCLUSION

(1) It has achieved success to retrofit a 25t/h pulverized coal-fired boiler into circulating fluidized bed boiler for burning mixture of coal and bagasse. The steam capacity of the CFB boiler reaches 35t/h. If necessary, the CFB boiler can burn coal alone or bagasse alone. In this case, the steam capacity and thermal efficiency of the boiler will decrease.

(2) The supply way of bagasse remains to be further studied and improved.

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