The Heat Loss Test and Calculation of 240t/h Circulating Fluidized Bed Boilers

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***Abstract*—Two 240 t/h circulating fluidized bed (CFB) boilers are choosed as the research object, through test CFB boiler parts surface temperature, surface conditions and the parts surface area, according to the standard ASME boiler body heat loss. The results showed that special separator inlet section of CFB boiler, cyclone separator and back material valve surface area accounts for 23% of the total area of the boiler body, surface temperature and environmental temperature significantly higher than the thermal insulation good furnace, the tail flue, heat losses to about 50% of total heat loss of boiler.**

Keywords-circulating fluidized bed; heat loss; surface area

I. INTRODUCTION

The boiler heat loss is an important part in the boiler performance appraisal. Rated load current domestic power plant boiler heat loss in general the GB10184-88 《Performance test code for utility boiler》illustration method, the method by the boiler capacity corresponding to determine the heat loss, can not reflect the differences between the boiler heat loss[1-3].

The large capacity CFB boiler on the structure of a pulverized coal furnace is complex, separator inlet section, cyclone separator and back material valve equipment increases the surface area of the boiler. Heat loss is also affected by the factors such as environmental temperature, air velocity. Heat loss measurement error has seriously affected the accuracy of the boiler thermal efficiency[4-6]. At present, the CFB boiler on boiler combustion efficiency is higher, low requirement for coal and the adjusting range is extensive running load, the ratio of power plant boiler has large improvement in our country, studies of CFB boiler heat loss, in order to obtain more accurate boiler efficiency is of great significance[7].

In this paper, by measuring the average surface temperature and two sets of CFB boiler is close to the environmental conditions on the surface of the boiler, the actual surface area of the components, according to ASME standard of boiler heat loss is calculated[8, 9].

II. THE COOLING TEMPERATURE MEASUREMENT

A. The Expermental Object

Two of a self-provided power plant the same model, structure of 240 t/h CFB boilers are taken as the research object. The design of boiler is superheater outlet steam pressure for 12 MPa, rated steam temperature for 540 ℃. The boiler is made up of the membrane type water wall, thermal insulation plate type cyclone separator， return valve , and the tail flue of heating surface etc. During the test, the 1 # boiler load of 70% rated load, 2 # boiler load of 100% rated load, both boilers burning the Russian coal.

B. Testing Content and Method

The thermocouples were used for entrance section of the furnace, separator, cyclone separator and rotary collector, the place such as the tail flue surface temperature measurement. Then the thermal imager was used to measure the same point, adjust the emission rate (emissivity epsilon material 0.8) until the thermal imager test results close to the thermocouple measurements. During the test, the thermal imager should be maintained vertical with the measured surface as possible. Using a handheld thermometer and anemometer to measure air temperature, air velocity of all parts of boiler[10].

III. RESULTS AND DISCUSSION

A. Cooling Area

TABLE I. THE CALCULATION RESULTS OF DIFFERENT PARTS OF BOILER

/	***Surface area*** （m^2）	***Proportion*** （%）
furnace	1543.52	36.68
separator inlet section	280.00	6.65
cyclone separator	500.00	11.88
return valve	180.00	4.28
tail flue	1704.96	40.51
total	4208.48	100

The surface area of each part of the boiler as shown in Table 1, the boiler body surface area are more than 4200m^2, the proportion of the tail flue surface area is 40.51%, furnace accounted for 36.68%. The total area of CFB unique separator inlet section, cyclone separator and return material accounted for 23% of the total area of the boiler body. The surface area of three parts of cyclone separator accounted for 11.88%，return valve in the proportion of the surface area of a minimum of 4.28%. The surface area of various parts of CFB boiler was significantly higher compared with

pulverized coal furnace, so the CFB boiler heat loss have some differences with the pulverized coal furnace.

B. The Surface Temperature and Environment Temperature

TABLE II. THE AVERAGE SURFACE TEMPERATURE ,ENVIRONMENT TEMPERATURE AND THE IMMEDIATE SURFACE AIR VELOCITY OF EACH PART OF THE BOILER 1#

/	***Average temperature*** （℃）	***Ambient temperature*** （℃）	***Temperature difference*** （℃）	***Air flow rat*** （***M/s***）
furnace	62.79	35.55	27.24	0.30
separator inlet section	88.97	30.10	58.87	0.21
cyclone separator	93.94	30.10	63.84	0.21
return valve	99.95	30.10	69.85	0.21
tail flue	65.13	34.35	30.78	0.26

The table 2 resents the average surface temperature, environment temperature and the immediate surface air velocity of each part of the boiler 1#. Table 3 is the average surface temperature, ambient temperature and the immediate surface air velocity of each part of the boiler 2#.

TABLE III. THE AVERAGE SURFACE TEMPERATURE,ENVIRONMENT TEMPERATURE AND THE IMMEDIATE SURFACE AIR VELOCITY OF EACH PART OF THE BOILER 2#

/	***Average temperature*** （℃）	***Ambient temperature*** （℃）	***Temperature difference*** （℃）	***Air flow rate*** （***m/s***）
furnace	66.42	41.6	24.82	0.36
separator inlet section	105.98	33.40	72.58	0.20
cyclone separator	113.08	33.40	79.68	0.20
return valve	109.05	33.40	75.65	0.20
tail flue	66.31	36.37	29.95	0.53

As shown in The table 2 and table 3,the average temperature of the separator inlet section, cyclone separator and return material valve of boiler 1 # and 2 # are higher than the furnace and tail flue, and the temperature is higher than the environment reach 60 ~ 80 ℃.The furnace and the tail flue heat preservation is better, the temperature difference about 30 ℃. Because of the two boiler body is indoor boiler island, the air temperature is higher and the air flow is slow, which can reduce the heat loss of the boiler.

C. *The Heat Loss Calculated In Accordance Based on Asme Standards*

Determination of the average surface temperature of the boiler, environment temperature and air velocity based on ASME standards, calculate heat loss QrLSrc caused by radiation and convection, calculated as follows:

$$QrLSrc = Cl\sum\left(Hcaz + Hraz\right)Afz\left(TMnAfz - TMnAz\right) \quad (1)$$

In the formula, $Hcaz = \max\begin{cases} 0.2\left(TMnAfz - TMnAz\right)^{1/3} \\ 0.35VAZ^{4/5} \end{cases}$

$$Hraz = 0.847 + 2.367E^{-3}TDi + 2.94E^{-6}TDi^{2} + 1.37E^{-9}TDi^{3} \quad (2)$$

Hcaz- a region z where the convective heat transfer coefficient, Btu/ft2·h·°F

Hraz- a region z of radiation heat transfer coefficient, Btu/ft2·h·°F

Afz- position z plane projection area of the outer insulation sheeting,ft^2;

TMnAfz- a region z surface average temperature, °F;

TMnAz- position z average ambient air temperature, °F;

$TDi = \left(TAfz - TAz\right)$, temperature difference;

VAz- the average flow rate of the air near the surface, ft/sec（or m/s）。

Cl-1.0（US units）

TABLE IV. THE PARTS CALCULATED HEAT LOSS BASED ON ASME STANDARDS OF BOILER 1#

/	***Convective heat loss*** （***%***）	***Radiant heat loss*** （***%***）	***Heat loss*** （***%***）
furnace	0.14	0.18	0.32
separator inlet section	0.07	0.08	0.15
cyclone separator	0.13	0.16	0.29
return valve	0.05	0.07	0.12
tail flue	0.19	0.24	0.43
total	0.58	0.73	1.31

TABLE V. THE PARTS CALCULATED HEAT LOSS BASED ON ASME STANDARDS OF BOILER 2#

/	***Convective heat loss*** （***%***）	***Radiant heat loss*** （***%***）	***Heat loss*** （***%***）
furnace	0.05	0.07	0.12
separator inlet section	0.05	0.06	0.11
cyclone separator	0.11	0.13	0.24
return valve	0.04	0.04	0.08
tail flue	0.08	0.10	0.18
total	0.33	0.40	0.73

Table 4 presents the boiler 1 # body calculated convection heat loss, radiation heat loss results, table 5 presents boiler 2# body calculated convection heat loss, radiation heat loss results.

From table 4 and table 5, we can see that the radiation heat loss of boiler 1# and boiler 2# in heat loss is dominant, radiant heat loss in the total heat loss rates is 56% and 55% respectively. The total of three parts surface areas which are the unique of CFB boiler is 23%.the heat loss of boiler 1# and boiler 2# is 43% and 59% respectively. Boiler # 1

running load is lower than boiler # 2, but the heat loss of boiler 1 # is 1.8 times than boiler # 2.Therefore, when the boiler is non-full-load operation, the heat dissipation is increased. The largest part convection and radiation heat loss of boiler 2# is cyclone separator which reached about 33% and is accounting for 0.24% of the total heat loss.

IV. CONCLUSIONS

1) The surface area of CFB boiler unique separator inlet section, cyclone separator, return feed valve is larger. The experimental study three parts areas in boiler body area is about 23%, and the surface temperature is significantly higher than the furnace, tail flue. The surface temperature of the boiler 2# cyclone separator highest reached 113℃ and the temperature is higher than the encironment about 80℃.

2) According to ASME standard to calculate the radiation heat and convection heat loss, radiant heat loss is main heat loss. The heat loss of three parts surface which are the unique of CFB boiler in boiler 1# and boiler 2# body heat loss is 43% and 59% respectively. The heat loss of boiler 2# cyclone separator is 0.24%, which is the largest component of the heat loss of boiler.

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REFERENCES

[1] YAN W P, DU H L.Uncertainty Calculation method and example in efficiency test of boiler.Boiler Technology , 5rd ed., vol. 41. 2010,pp. 10-13.

[2] Kline S J, McClintock F A.Describing uncertainties in single-sample experiments. Mechanical Engineering, 1rd ed., vol. 75,1953,pp.3-8.

YANG T,WANG X B,LIU Q.The influence of uncertainty in temperature testing upon the results of measuring thermal eddiciency. for boilers.Thermal Power Generation , 6rd ed., vol. 32.2003,pp. 26-27.

[3] WANG Z G, MA Y T, LU W.The application of uncertainty analysis theory in thermal efficiency testing for boiler.Proceedings of the CSEE, 3rd ed., vol. 25.2005,pp,125-129.

[4] Gao Chunyang, Liu Yanhua, Che Defu. Economical evaluation of retrofitting natural gas fired boiler into condensing boiler. EnergyConservation Technology, 5rd ed., vol. 21.2003,pp,8-11.

[5] Liu Z M, Liu F. Evaluation and expression of uncertainty inmeasurement.Chemical Abstract by the American Chemical Society, 14rd ed., vol. 25.1996, pp.756-759.

[6] TANG S T, WANG Z Wi, LI D K, et al.Study on primeval teansffering phenomen on in the fluidized bed.Thermal Power Generation, 11rd ed. 2003,pp.41-44.

[7] LV D Z, DUAN X N, CHEN Y P, et al.Effect of measurement uncertainty on test quality of boiler thermal efficiency.Thermal Power Generation, vol. 43.2014,pp.54-58.

[8] ASME PTC 4-2008 Fired Steam Generators Performance Test Codes.

[9] LIU Z K. The loss Heat Measurement and Calculation of 300MW Circulating Fluidized Bed.Railway Construction Technology. 2011Add Edition ,pp.259-261.