Study on test of coal co-firing for 600MW ultra supercritical boiler with four walls tangential burning

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Abstract. On account of nine commonly used coals in a Jiangxi Power Plant,two kinds of coal were selected to be applied in coal co-firing test through industrial analysis,elementary analysis and thermogravimetric analysis of coal.During the coal co-firing test,two load points were selected,three coal mixtures were prepared.Moreover,under each coal blending scheme,the optimal oxygen content was obtained by oxygen varying test.At last,by measuring the boiler efficiency and coal consumption of power supply in different coal co-firing schemes,the recommended coal co-firing scheme was obtained.

1 Introduction

A power plant in Jiangxi is affected by the location, capacity and so on. The coal entering the furnace is mostly local automobile coal, and the coal quality is changeable. Mixing coal with coal becomes the inevitable choice of the plant. However, the previous attempts to mix coal in the power plant were carried out with a simple weighted average, and the limitations were large. The mixed coal is too simple and rough, resulting in a lot of cases, boiler load capacity fluctuations, but also easy to bring the boiler reheat steam temperature low, low combustion efficiency, affect the economic operation of units [1-2]. Therefore, this paper adopts the method of theoretical research and field test to study the coal blending and burning test of No. 1 boiler in a power plant in Jiangxi, which provides a scientific basis for the power plant coal, coal and boiler operation.

2 Equipment Profile

No. 1 boiler of a power plant in Jiangxi is designed and manufactured for Harbin boiler works. The model is HG-2035/26.15-YM3. The boiler shape layout, single furnace, improved low NOX PM MACT low NOx main burner and staged air combustion system, wall tangential firing mode. The boiler adopts one intermediate reheat, balanced ventilation, tight closed arrangement, solid slag discharge, all steel frame and full suspension structure. The main design parameters of boiler are shown in table 1.

Table 1. Main design parameters of boiler.

Parameter	Unit	BMCR	BRL
Evaporation capacity	t/h	2035	1938
Main steam temperature	℃	605	605
Main steam pressure	MPa	26.15	26.04
Feed water temperature	℃	296	293
Flue gas temperature (before correction)	℃	127	125
Flue gas temperature (after correction)	℃	122	120
Boiler calculation efficiency (low)	%	93.97	94.05
Evaporation capacity	t/h	2035	1938

3 Test characteristics of coal

The combustion characteristics of pulverized coal have an important influence on the operation of boiler [3]. According to a large number of coal blending tests show that by different kinds of coal mixed coal, although in the industry, the elemental analysis of coal quality index is not significantly different, but the coal ignition, combustion and burnout, stable combustion and combustion characteristics of different [4-5]. Therefore, industrial analysis, elemental analysis and thermogravimetric analysis of 9 commonly used coal-fired power plants are provided. The results are shown in table 2~4.

Table 2. Proximate analysis of test coal.

Coal sample	Mt /%	Mad /%	Vad /%	Aad /%	St,ad /%	Qb,ad MJ/kg	HGI
Xinji Coal	8.1	0.9	29.71	28.73	0.26	21.04	72
XingyeCoal	8.1	0.63	9.54	56.72	0.47	11.95	76
Xing Coal No.1	9.90	1.57	27.45	24.56	1.31	21.06	66
Lu'an Xiadian Coal	10.10	1.50	9.91	26.24	0.26	22.36	98
Yanan Zhongsheng Coal	15.70	8.02	27.75	15.68	1.91	22.18	88
Datong Coal	6.90	3.27	26.48	24.77	0.64	21.56	69
Pankuang Coal	6.2	1.95	26.24	29.82	0.23	21.38	59

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Yangou Coal	10.3	0.79	8.44	48.52	0.67	14.42	98
Indonesian Coal	15.23	6	39.36	8.95	0.81	23.09	50

Table 3. Elemental analysis of test coal.

Coal sample	Mt /%	Mad/%	Aad /%	Cad /%	Nad/%	Had/%	Oad/%
Xinji Coal	8.1	0.9	30.79	53.69	0.98	3.74	8.24
XingyeCoal	8.1	0.63	54.08	36.76	0.78	1.7	3.99
Xing Coal No.1	9.90	1.57	24.56	59.09	1.04	3.74	8.69
Lu'an Xiadian Coal	10.10	1.50	26.24	64.17	1.14	2.84	3.85
Yanan Zhongsheng Coal	15.70	8.02	15.68	63.64	0.84	3.48	6.43
Datong Coal	6.90	3.27	24.77	57.74	0.97	3.47	9.14
Pankuang Coal	6.2	1.95	29.82	57.01	0.9	3.64	6.45
Yangou Coal	10.3	0.79	48.52	41.02	0.84	2.02	6.14
Indonesian Coal	15.23	6	8.95	61.84	1.38	4.82	16.2

Table 4. Thermogravimetric analysis of test coal.

Coal sample	Ignition temperature Ti /℃	Burnout temperature Th /℃	Remarks
Xinji Coal	457.3	635.0	Easy to catch fire, easy to burn out
XingyeCoal	521.6	728.8	Hard to catch fire, hard to burn out
Xing Coal No.1	449.7	659.3	Easy to catch fire, easy to burn out
Lu'an Xiadian Coal	510.0	680.1	Hard to catch fire, easy to burn out
Yanan Zhongsheng Coal	444.3	631.1	Easy to catch fire, easy to burn out
Datong Coal	437.5	650.2	Easy to catch fire, easy to burn out
Pankuang Coal	456.9	652.4	Easy to catch fire, easy to burn out
Yangou Coal	516.6	717.6	Hard to catch fire, easy to burn out
Indonesian Coal	375.9	590.5	Easy to catch fire, easy to burn out

There are a lot of coal combustion characteristics of evaluation indicators, such as the dynamics of three factor[6], stable combustion and burnout characteristics index R[7] index[8], Fu Zhang index Fz[9], the comprehensive combustion characteristic index[10], the influence of the combustion characteristics of the pulverized coal is decomposed into two indicators to discuss: one is on fire, burning out is two. The former index considers the safety and stability of pulverized coal combustion in boiler, and the latter index considers the economy of combustion of pulverized coal in boiler [11-13].

According to the relevant data and using thermogravimetric analyzer in the laboratory for multiple kinds of coal combustion characteristics test of the statistical data shows that the ignition of coal difficult situation is divided into three categories: the[14] temperature are less than 450℃ fire for fire easily; the temperature at 450℃ ~500℃ range of fire is easy to fire the temperature more than 500℃; the fire is not easy to fire. Similarly, the coal burning out difficult situation is divided into three categories: the burnout temperature are less than 650 ℃ for easy burnout; the burnout temperature at 650℃~700℃ range is easy to burn; the burnout temperature more than 700℃ is not flammable.

Thermogravimetric analysis of 9 coal samples was carried out by using a comprehensive thermal analyzer. Because of the limited space, here only to Xinji coal is analyzed, the thermal analysis curves as shown in figure 1.

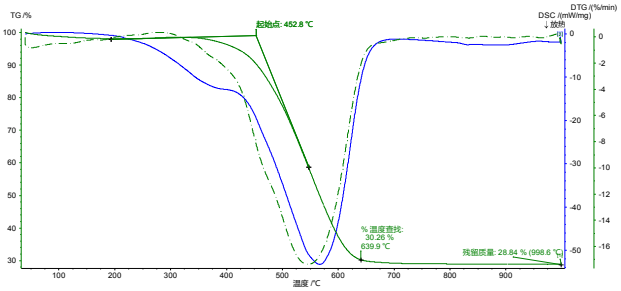

Fig. 1. Thermogravimetric analysis curve of Xinji coal.

Seen from Figure 1, Xinji coal ignition temperature is 452.8 ℃, combustion temperature is 639.9 ℃, is relatively easy to fire, easy to coal burning out.

4 Blending burning plan of coal blending

At present, blended coal mixing mainly has 2 ways: mixing before furnace, mixing in furnace (referred to as mixing before furnace) and sub grinding, mixing furnace (referred to as "grinding, mixing, burning")[15-18]. In this paper, the method of "mixing before furnace" and "mixing in furnace" is adopted.

Mixed coal is usually mixed with 2 or 3 single coals. If the mixture of coal is too much, it may lead to higher costs and more complicated combustion. Therefore, a combination of 9 coal industry analysis, elemental analysis and thermogravimetric analysis results and the existing coal yard power plant, the on-site mixed coal experiment selected 2 kinds of coal blending, which is outside the local coal quality ratio of lean coal.

Because the Xingye coal belongs to low calorific value, high ash content of inferior coal, in order to ensure the normal boiler load capacity, the power plant and consultation, and determine the Xinji Coal maximum mixing ratio does not exceed 30% (weighted value of 18314 kJ/kg). According to the results of coal quality analysis, a blending scheme for coal blending is worked out, as shown in table 5.

Table 5. Blending scheme.

Serial number	Experiment content	Mixed coal scheme	Coal loading mode
1	Oxygen change 1, Oxygen change 2, Oxygen change 3	Scheme 1 (Xinji coal: Xingye coal=8:2), four grinding operation；600MW	Xinji coal and Xingye coal mixed in BCEF mill
2	Oxygen change 1, Oxygen change 2, Oxygen change 3	Scheme 2(Xinji coal: Xingye coal =7:3),five grinding operation；600MW	Xinji coal and Xingye coal mixed in BCDEF mill
3	Oxygen change 1, Oxygen change 2, Oxygen change 3	Scheme 3(Xinji coal: Xingye coal =7:3),four grinding operation；450MW	Xinji coal and Xingye coal mixed in BCEF mill
4	Oxygen change 1, Oxygen change 2, Oxygen change 3	Scheme 4(Xinji coal: Xingye coal =8:2),five grinding operation；450MW	Xinji coal and Xingye coal mixed in BCDEF mill
5	Oxygen change 1, Oxygen change 2, Oxygen change 3	Scheme 5,four grinding operation；450MW	Xinji coal mixed in BEF mill,Xingye coal in C mill

5 Test result analysis

The blending test of blending coal is carried out under the 600MW and 450MW loads according to table 5. The main test results of each working condition are shown in table 6.

Table 6. Test results of different conditions.

Mixed coal scheme	O2 (%)	Boiler efficiency (%)	Auxiliary power consumption(%)	Power consumption of main auxiliary machine (%)	Coal consumption of power supply(g/kW.h)
1	2.52	92.07	4.489	1.750	298.42
	2.95	92.88	4.500	1.774	294.63
	3.46	92.48	4.524	1.794	298.11
2	2.44	91.61	4.025	1.623	295.49
	3.05	92.80	4.031	1.646	292.94
	3.48	91.74	4.062	1.664	294.30
3	4.01	92.85	4.799	2.033	303.06
	4.42	92.43	4.802	2.091	304.44
	4.95	92.34	4.831	2.112	304.83
4	4.01	93.47	4.435	1.953	299.90
	4.47	92.89	4.471	1.997	301.88
	4.94	92.78	4.483	2.006	302.28
5	4.01	93.23	4.937	2.121	302.26
	4.48	93.08	4.942	2.146	302.76
	4.99	92.86	4.953	2.164	303.51

As shown in table 6:

1)Under the 600MW load, the minimum coal consumption is 292.94 g/kW.h, the maximum is 298.42

g/kW.h, the maximum and minimum difference is 5.48 g/kW.h. The highest coal coal consumption for Xinji Coal: Coal Industrial 7:3 ratio, outlet oxygen economizer is set to 2.5; the minimum coal consumption of coal blending for Xinji Coal: Coal Industrial 8:2 ratio, outlet oxygen economizer is set to 3.

2)Under the 450MW load, the minimum coal consumption is 301.88 g/kW.h, the maximum is 304.83g/kW.h, the maximum and minimum difference is 2.95g/kW.h. The highest coal coal consumption for Xinji Coal: Coal Industrial 7:3 ratio, outlet oxygen economizer is set to 5; the minimum coal consumption of coal blending for Xinji Coal: Coal Industrial 8:2 ratio, outlet oxygen economizer is set to 4.5.

3)In the same load, the Xinji coal coal blending scheme: Industrial 8:2, plant auxiliaries #1unit boiler side power rate and the electricity rate is lower than the Xinji Coal: Coal Industrial 7:3 mixed mode; in 450MW load, using C single industrial coal grinding. The furnace side power plant was the highest.

4)The boiler coal blending combustion method and oxygen change test have little influence on the power consumption of the plant, and the important factor affecting the coal consumption in the test is boiler efficiency.

5)Considering the economy of the unit, the proposed 450MW uses Xinji Coal: coal blending scheme of industrial =8:2. 600MW uses Xinji Coal: Coal Industrial 8:2 ratio, outlet oxygen economizer is set to 4.5.

6 Epilogue

In this paper, theoretical research and field experiments are combined to study the coal blending burning test of boiler No. 1 in a power plant in Jiangxi. The test results show that the boiler coal blending method and the oxygen change test have little influence on the power consumption of the plant, and the important factor affecting the coal consumption in the test is the boiler efficiency. 600MW load under different coal blending scheme under the boiler efficiency maximum difference of 1.14%, coal consumption is 5.48 g/kW.h maximum, 450MW load, different coal blending scheme under the boiler efficiency, the biggest difference is 1.13%, the maximum difference of 2.95 g/kW.h power supply coal consumption. Therefore, the reasonable coal blending scheme can significantly improve the boiler safety and economy.

References

1. WANG Wenhuan,PAN Bingchao,et al. Analysis of the Economy and Environmental Protection Features Based on Blending Lignite in Coal-fired Boiler,Boiler Technology, 2014,45(2):67-71.
2. CHEN Guodong, YUAN Yichao, WANG Bo. Application of Power Plant Boiler Blended Coal Combustion Technology,Boiler Technology, 2014, 45(5):53-57.
3. WANG Lingling, LU Zhimin, et al.Thermo-gravimetric study on dynamic characters in combustion reaction of Indonesia coal blended with bituminous coal.Thermal Power Generation, 2009, 38(3)：69-71.
4. LIU Jingyan,WANG Changan,et al. Investigation on Coal Properties and Combustion Characteristics of Blended Coals,Boiler Technology, 2012, 43(2):37-42.
5. WU Ying, CHEN Linguo, LI Haishan, et al. Study on test of coal co-firing for 700MW supercritical once-through. Power System Engineering, 2014, 30(3):24-26.
6. HU Rongzu, SHI Qizhen, et al. Thermal analysis kinetics[M]. The Science Publishing Company, 2001, 12-13.
7. ZENG Lingda, CHEN Qijuan, XIONG Jie, et al. Thermogravimetric test on combustion characteristics of blend coal and type selection suggestions of 680MW ultra-supercritical boiler[J]. Journal Of Power Engineering, 2008, 28(5):672-676.
8. LOU Bo, WANG Xiaocong. Thermogravimetric experimental study of mixed combustion of sewage sludge and coal [J]. Journal of Engineering for Thermal Energy and Power, 2011,26(1) :114-116.
9. HEN Bingyun, XUN Hua, HAN Jianchun. Analysis of combustion characteristics of the mixture of coal washing and coal gangue[J].Journal of Engineering for Thermal Energy and Power, 2011,26(5) :571-575.
10. XIAN Xiaohong, DU Yungui, ZHANG Guanghui. Combustion characteristics of coal blending by TG-DTG/DTA [J].Coal Conversion, 2011,34(3) :67-70.
11. XIANG Yi,ZHAO Weidong,et al.Thermogravimetric experiments and reaction kinetics analysis on combustion of indonesia lignite and shanxi bituminous coal. Thermal Power Generation, 2015, 44(11):14-19.
12. GONG Dehong,ZHANG Zhongxiao,et al. Effects of pulverizing method and oxygen content on combustion characteristics of mixed coal and the kinetic analysis.Thermal Power Generation, 2016, 45(10):40-49.
13. CHANG Jiaxing,YANG Zhongcan. Study on Zhundong Coal's Ash Fouling Indicator to Ensure Safe Operation of Boilers,Boiler Technology, 2013, 44(6):17-19.
14. MAO Xiaofei, WU Ying, ZENG Guofang, et al.Experimental research on blended coal combustion in a 700MW unit boiler. Thermal Power Generation, 2014, 43(5):69-74.
15. DUAN Xuenong, ZHU Guangming, JIAO Qingfeng, et al. Research and practice of blended coal combustion technology in power plant boiler[J]. Electric Power, 2008, 41(6):51-54.
16. ZHOU Zhen, LIU Liang, YAN Xiaozhong.Adjustment test and analysis of off-

design coal combustion of 1025t/h boiler,Power System Engineering, 2008,24(4):35-38.

17. WANG Qunying,SU Pan,et al. Influence of blending lignite with bituminous coal on coal feeding safety and operational costs for a 660 MW unit boiler. Thermal Power Generation, 2015(10):9-14.
18. HUA Xiaoyu,WANG Ruikun,et al.Anti-balancing efficiency and its uncertainty analysis of boiler burning mixed coal according to ASME and GB standard. Thermal Power Generation, 2016, 45(3):34-40.