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A New Distinguish Method of Blending Coals Slagging Characteristic

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Abstract

The slagging characteristic of coal effects the safe operation of boiler unit directly, the study on coal slagging is paid more and more attention by scholars of the world. Because of the complexity of coal characteristic, the blending coals slagging characteristic is more complex than single coal. The study method of blending coals characteristic is the same as the single coal method, but the simple method can't distinguish the blending coals slagging characteristic well and truly. This paper gives the new distinguish method of blending coals slagging characteristic based on experimentation condition, it is the rate of slag and furnace refuse. The rate of slagging on furnace wall and the refuse on furnace bottom has utilized to distinguish the slagging characteristic of coal. The result shows that the rate of slag and furnace refuse method has better veracity.

1. Introduction

The slagging characteristic of coal effects the safe operation of boiler unit directly. So, scholars of the world attach importance to the study of coal slagging. At present, the study of slagging characteristics of blending coals is depended on the study of single coal.

The fuel character, boiler structure and operation mode are the factors of deciding boiler slagging. The fuel character is the basic of boiler design and operation. So, the study on fuel slagging characteristic is important. The study on distinguish slagging character is paid more and more attention by scholars. There are many distinguish methods and index of single coal slagging characteristics. The most of the methods are ash melting temperature slagging index method, ash element slagging index method, ash viscosity slagging index method, special type method and integrative distinguish method [1-3].

In USA, every slagging distinguish method are studied in 130,300 MW and upwards units. The results show that no method can forecast slagging trend complete accurately. The resolution of the softening temperature and silicon aluminum ratio is the highest. Harbin complete institute distinguishes the slagging trend of 250 kinds of Chinese coal; the resolution is 65%. Harbin boiler factory and Harbin Institute of Technology study on lignite slagging trend, the results show that the resolution of the softening temperature and silicon aluminum ratio is 74%

[4].

Some scholars adopt ash element slagging index method and ash liquation index [5], ash melting temperature [6], supporting vector machine [7], base/acid and silica/alumina [8], to study coal slagging characteristic.

Many scholars study on blending coals slagging characteristics [9,10]. They consider that the slagging character of blending coals is more complex than single coal because of the complex of single coal slagging character. The blending coals research method is the same as single coal research method, but it can't distinguish blending coals slagging trend by single coal slagging trend. It means that the difference of slagging character between blending coals and singles coal is great.

This paper gives the new distinguish method of blending coals slagging characteristic based on experimentation condition, it is the rate of slag and furnace refuse. The rate of slagging on furnace wall and the refuse on furnace bottom has utilized to distinguish the slagging characteristic of coal.

2. Test Rig and Experimental Process [11]

2.1. Coal Analysis

The single coal analysis and the rate and numbers of blending coals are shown in **Table 1** and **Table 2**.

Table 1. Single coal analysis.

Coal		Huolinhe	Yangcaogou	Fengguang	Meihe
Proximate analysis (%)	M_{ad}	12.22	7.01	8.60	5.89
	A_{ad}	24.42	43.43	51.39	22.68
	V_{ad}	30.75	22.95	24.34	35.18
	FC_{ad}	32.61	26.61	15.67	36.25
Ultimate analysis (%)	C_{ad}	45.91	35.82	26.74	52.24
	H_{ad}	2.70	3.21	2.42	4.04
	S_{ad}	0.50	0.35	0.18	1.65
	N_{ad}	0.73	0.53	0.73	1.38
	O_{ad}	13.52	9.65	9.94	12.12
$Q_{net, ar}$ (J/g)		15919	12388	9249	19819

Table 2. The rate and number of blending coals.

No.	The rate of single coal (%)			
	Huolinhe	Meihe	Fengguang	Yangcaogou
1#	80	20	0	0
2#	70	30	0	0
3#	80	0	20	0
4#	70	0	30	0
5#	80	0	0	20
6#	70	0	0	30
7#	60	20	10	10
8#	70	10	10	10
9#	0	40	30	30

2.2. Test Rig

This study is conducted at Combustion Research Facility (CRF) test rig, which is introduced from Canada. It's designed for a maximum coal feed rate of 20 kg/h medium sulfur coal at a firing rate of 640 MJ/h (see **Figure 1**). Its advantages are complete equipment, advanced control system, on-line measurement and recurring of experimental result.

The test rig is composed of five systems, which are the combustion system, data acquisition and control system, compressing air and cooling system, the system of sampling and analysis of flue gas and milling system. The furnace is a refractory-lined cylindrical chamber, composed of four identical modules, the bottom three with cylindrical cooling jackets. It is 3.6 m high, and 0.3 m in diameter. The furnace temperature is measured by plati-

num-rhodium thermocouple. The flue gas that leaving the furnace is continuously monitored by O_2, NO_x, CO_2, CO and SO_2 analyzers. The slag is got in the cooling drawer at the bottom of the furnace and the fly ash is sampled at the bottom of ESP. The coal feed rate of 20 kg/h.

2.3. Experimental Process

In this paper, the slag is got in the water-cooling drawer at the bottom of the furnace, the fly ash is sampled at the bottom of ESP. The coke adhered to furnace wall. The coke is scratched from wall after test.

3. Test Results and Discussion

Slagging is a complex physical and chemical process. It is not only related to the composition of coal ash, but also influenced by the type of burners, the structure of furnace, the temperature level in furnace, the aerodynamic field of furnace and atmosphere in furnace. Now, there are a few methods to predict and estimate the slagging of pulverized-coal combustion, such as ash fusion, ash composition and ash viscosity, but none of them is accurate enough to predict correctly in practice.

According to the conditions of the test rig, this paper got the ratio of the amount of coke attached to the wall to the amount of slag on the bottom of the furnace. It is presented as a discriminant parameter of slagging and used to evaluate the extent of slagging in furnace in this paper. The bigger the ratio is, the easier the slagging happens. **Table 3** shows the result of the ratio of coke and slagging. On the basic of **Table 3**, the tendency of

Table 3. The ratio of the coke attached to furnace wall over the slag on bottom of furnace.

Serial number	Blending Coals	Coke/slag
1	9#(4M + 3F + 3Y)	2.92
2	Meihe	1.89
3	2#(7H + 3M)	1.84
4	5#(8H + 2Y)	1.44
5	Yangcaogou	1.27
6	7#(6H + 2M + 1F+1Y)	1.12
7	1#(8H + 2M)	1.17
8	6#(7H + 3Y)	1.11
9	3#(8H + 2F)	0.97
10	8#(7H + 1M + 1F + 1Y)	0.96
11	4#(7H + 3F)	0.53

Figure 1. CRF test rig.

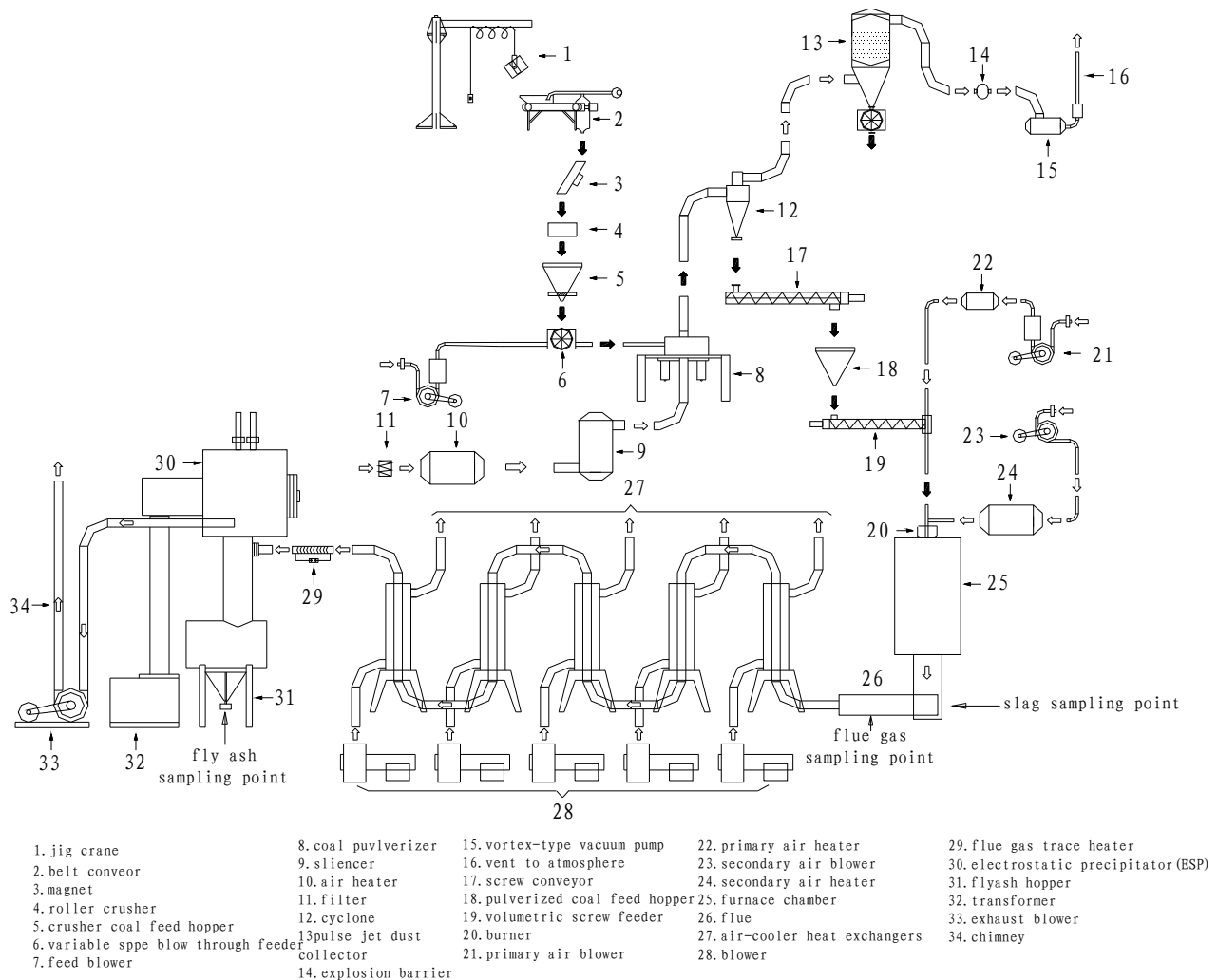|				
1. jig crane	8. coal puvlverizer	15. vortex-type vacuum pump	22. primary air heater	29. flue gas trace heater
2. belt conveor	9. sliencer	16. vent to atmosphere	23. secondary air blower	30. electrostatic precipitator(ESP)
3. magnet	10. air heater	17. screw conveyor	24. secondary air heater	31. flyash hopper
4. roller crusher	11. filter	18. pulverized coal feed hopper	25. furnace chamber	32. transformer
5. crusher coal feed hopper	12. cyclone	19. volumetric screw feeder	26. flue	33. exhaust blower
6. variable sppe blow through feeder	13 pulse jet dust collector	20. burner	27. air-cooler heat exchangers	34. chimney
7. feed blower	14. explosion barrier	21. primary air blower	28. blower	

slagging of Meihe coal and 5#(2Y8H) coal is obvious, while that of Huolinhe coal is weak. It fundamentally agrees with the practice slagging tendency in boilers of Shuangliao Power Plants on the whole. The ratio of coke and slagging is a reasonable discriminant parameter of slagging. From slagging characteristic of Meihe coal, 2# coal, Yangcaogou coal, 1# coal, 6# coal, Huolinhe coal, the results show that the slagging characteristic of blending coals is between componential coals basically. The slagging serious coal changed the slagging characteristic by blended not easy slagging coal, thereby achieved the aim that lighten slagging.

According to the **Table 3**, the slagging property of 9# (4M3F3Y) coal and Meihe coal is more serious than that of Huolinhe coal and Yangcaogou coal. This shows when the blending of a coal of high slagging potential with another coal with low slagging potential is used, the trouble of slagging perhaps gets worse instead of getting better. This is because the eutectic phenomenon of ash

composition makes the ash fusion of the mixed coal lower than that of any of the coals used in the blending. Therefore, improper blending of coals will cause serious slagging.

4. Compared with Other Methods

4.1. Slag Type Analysis

From the slag scratched from wall, the slag color of Meihe coal, No. 9 and No. 2 blending coals is hoar and dust color. It has alveolate hole. The intensity is high and rigidity is great. The surface of slag is smooth. It belongs to glaze type slag. It shows that the slagging is serious. The slag color of Yangcaogou coal, No. 1, No. 7 and No. 5 blending coals is black, the character is relaxation. It shows that the slagging is middling. No. 3, No. 4, No. 8, No. 6 blending coals and Huolinhe coal slagging is lightly.

Table 4. Fusion behavior of coal ash.

Coal	Ash fusion point Tem. at oxidizing atmosphere (°C)			Ash fusion point Tem. at reducing atmosphere (°C)		
	DT	ST	FT	DT	ST	FT
Huolinhe	1280	1395	>1450	1230	1345	>1450
Yangcaogou	1250	1410	>1450	1200	1360	>1450
Meihe	1320	1360	1430	1270	1310	1380
Fengguang	>1450	-	-	>1450	-	-
1#	1245	1340	>1450	1195	1290	>1450
2#	1220	1325	1440	1170	1275	1390
3#	1270	1365	1450	1220	1315	1400
4#	1305	1405	1450	1255	1355	1400
5#	1295	1380	1440	1245	1330	1390
6#	1235	1375	>1450	1185	1325	>1450
7#	1260	1330	1445	1210	1280	1395
8#	1220	1350	1445	1170	1300	1395
9#	1435	>1450	-	1385	>1450	-

Table 5. Distinguish result.

Method	Result
The rate of slag and furnace refuse	9#, Meihe, 2#, 5#, Yangcaogou, 7#, 1#, 6#, 3#, 8#, 4#, Huolinhe
Slag type analysis	Meihe, 9#, 2#, Yangcaogou, 1#, 7#, 5#, 3#, 4#, 8#, 6#, Huolinhe
Fusion behavior analysis	Meihe, 1#, 2#, 3#, 6#, 5#, 8#, 7#, Huolinhe, Yangcaogou, 4#, 9#

4.2. Fusion Behavior Analysis

The fusion behavior of coal ash is shown in **Table 4**.

This paper adopts the Harbin boiler factory and Harbin Institute of Technology method distinguishes the slagging character. The result is that Meihe coal, No. 1, No. 2, No. 3, No. 6, No. 5, No. 8 and No. 7 blending coals slagging middling, Huolinhe, Yangcaogou, Fengguang coal, No. 4 and No. 9 blending coals slagging lightly.

4.3. Compare of Three Methods

Up to now, there is no method has 100% resolution. So, the test result is most important. The compare of three methods is shown in **Table 5**. The result shows that the rate of slag and furnace refuse method has better veracity.

5. Conclusions

This paper gives the new distinguish method of blending coals slagging characteristic based on experimentation condition, it is the rate of slag and furnace refuse. The result shows that the rate of slag and furnace refuse method has better veracity.

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