

The Analysis of Influence of the Gangue in the Coal as Fired on the Coal Conveying System and the Boiler Operation of the Circulating Fluidized Bed Unit

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Abstract. The coal as fired, with unidentified characteristics of the coal gangue, was burned on a 300MW circulating fluidized bed unit. The equipment of the coal conveying system was damaged and the boiler operation was unstable. In response to the problems, the coal quality data and storage conditions of the coal were examined and the site was spot-checked to evaluate the coal quality characteristics. At the same time, the typical representative parameters of the coal handling system and boiler operation were selected. According to the analysis of coal quality and coal storage, the coal quality fluctuates greatly and the uniformity of particle size distribution is poor. There is actually the coal gangue with hard texture and hard to grind in the coal pile. The coal gangue will have adverse effects on the fine screening machine, fine crusher and other equipment. After burned this type of coal, the fluidized quality of the boiler bed is degraded to make an impact on the safe and stable operation of the boiler. It is recommended that the coal should be screened and then burned into the furnace to ensure safe and stable operation of the boiler.

1 Introduction

As one of the important development directions in the field of coal-fired power generation, the power generation technology of the circulating fluidized bed has developed its 300MW grade circulating fluidized bed unit after decades of development due to its wide fuel adaptability, strong load regulation and excellent environmental performance. It has been widely used in domestic coal-fired power generation^[1-3].

The circulating fluidized bed boiler and the pulverized coal fired boiler have a very different combustion method^[4]. Although the circulating fluidized bed boiler has strong fuel adaptability^[5], it has strict requirements on the particle size and gradation of the fuel^[6-7]. The reason is the high temperature circulating ash in the boiler of the bed boiler has an important influence on the combustion^[8-9], heat transfer and load regulation in the furnace^[10-11]. With the consumption of high-quality coal sources in the coal industry, low-quality coal has received increasing attention in the thermal power generation market^[12]. There are coal gangues with hard texture and large granularity, which are among the low-quality coals, such as this type of coal. The circulating fluidized bed unit burns the coal, and the particle sizes characteristics of the crushed coal are changed^[13], which leads to an increase in the crushing power consumption of the crushing equipment in the coal conveying system^[14], and may adversely affect the safety and economical operation of the circulating fluidized bed unit^[15].

In this paper, a 300MW circulating fluidized bed unit was taken as the research object. Coal gangue with unidentified characteristics exists in the coal, and after burned the coal, the equipment of the coal conveying system was damaged and the boiler operation was unstable. In response to the above problems, the coal quality data and storage conditions of the coal were examined and the site was spot-checked to evaluate its coal quality characteristics. At the same time, according to the screening equipment of the coal conveying system and the operation of the boiler, the typical representative parameters of the coal handling system and boiler operation were selected. The influence of the coal gangue coal on the coal conveying system and the boiler operation of the circulating fluidized bed unit were mainly analyzed.

2 Equipment introduction

The 300MW unit of the power plant is equipped with a subcritical parameter circulating fluidized bed steam drum furnace produced by Dongfang Boiler Factory, model: DG1025/17.4-III18, natural circulation, single furnace, one intermediate reheat, steam-cooled cyclone, balanced ventilation, open-air layout, coal-fired, solid-state slagging, full-suspension on the heated surface, steel frame with double-row column steel structure, superheated steam flow 1025t/h, superheated steam outlet pressure 17.4MPa, superheated steam outlet temperature 540°C, reheat steam outlet pressure 3.705 MPa, the reheat steam outlet temperature 540°C, and

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the feed water temperature 281°C. The coal is designed into the furnace ($d_{max}=8.5mm, d_{50}=1.1mm$) and the unloading groove mesh screen has a square hole diameter of 200mm.

The coal handling system is arranged in two ways, one way of operation, one way of standby, with the conditions of simultaneous operation of two channels. In order to meet the requirements of the coal-fired particle size of the circulating fluidized bed boiler, the screening equipment of the coal conveying system adopts two-stage crushing and is arranged separately. The ring hammer coarse crusher feeding particle size $\leq 300mm$, discharge particle size $\leq 40mm$, output:800t/h; The sine sieving output 800t/h, feed size $\leq 40mm$, discharge size $\leq 8mm$; imported reversible hammering fine crusher The output is 600t/h, the feed size is $\leq 40mm$, and the discharge size is $\leq 8mm$.

3 Analysis of the coal quality and coal storage

The coal as received (referred to as "A coal") was the first purchase of coal on the power plant, a total of 25 batches, the total weight of 14000t, coal unloading time of 1-27d, and the coal storage volume of the dock with tens of thousands of tons. When the coal was unloaded for 17d, the iron mesh was sifted in the coal unloading grid of the train, and the large-size material (greater than 100 mm) in the coal were blocked from entering the coal conveying system by reducing the sieve diameter. After adopting this method, the coal train stayed frequently and the efficiency of unloading coal was significantly reduced. At 27d, the transportation of coal A was stopped.

In the plant, A coal was used as one of the coal-fired coals. The time for the boiler to burn A coal was 1-8d. During this period, there was no other coal for the first time in the boiler.

3.1 Coal quality data

Table 1 shows the average coal quality data of A coal as received. It can be seen from the table that A coal is the high volatile bituminous coal. The ash content of each batch of A coal is fluctuated between 45.80% and 27.10%, and the calorific value changes greatly. From the perspective of the analysis of the ash and calorific value, coal quality fluctuations are large, affected by the change of raw coal ash or the distribution of coal gangue in the whole batch of coal.

Table 1. A coal as received average coal quality data

parameter	unit	design value	maximum ash	minimum ash	Average value
M_t	%	9.0	6.4	10.3	8.8
A_{ar}	%	30.00	45.80	27.10	32.51
M_{ad}	%	1.56	1.60	2.40	1.98
V_{daf}	%	3.80	41.60	38.50	39.52
$Q_{net,ar}$	MJ/kg	20.68	13.70	19.20	17.68

3.2 Granularity

At present, A coal is stored in two large piles and one small pile in the coal yard. Figure 1 shows the storage map of some areas of A coal yard. On-site inspection found that the particle size distribution uniformity of coal in some areas is poor.



Fig. 1. The storage map of some areas of A coal yard

3.3 On-site sampling

The A coal storage area was selected randomly and the large pieces of coal on site (maximum diameter about 50mm) were collected, which looks like the shape of large coal on the outer surface. According to the characteristics of the coal gangue and coal block (under the same volume, the weight is obviously heavy gangue more likely), and four pieces of coal were selected (named sample 1, 2, 3, and 4, respectively). Sample preparation and laboratory analysis were carried out on 4 samples. Table 2 shows the coal quality data of sample samples collected from A coal. As shown in the table, the ash content of samples 1 and 3 is extremely high, and the heat generated at the low level of the base is extremely low, assessed as the coal gangue. Sample 2, 4 coal quality data is normal, assessed as the large coal. Four samples were subjected to the hardgrove grindability test. Samples 1 and 3 of the coal gangue were evaluated for hardgrove grindability index(HGI) of 51 and 54 respectively. Samples 1 and 2 were evaluated for HGI of 70 and 71, the HGI of coal gangue and bulk coal differs by about 20. According to "Coal hardgrove grindability index classification"(MT/T852-2000), coal gangue is a more difficult to grind grade, and large coal is a medium grindable grade.

Table 2. the coal quality data of sample samples collected from A coal

sample	M_t / %	M_{ad} / %	A_d / %	V_{ad} / %	Q_{net} / MJ/kg	results evaluation	HG I
sample 1	1.4	0.78	88.29	8.94	0.95	coal gangue	51
sample 2	3.2	1.94	27.85	24.41	21.66	large coal	70
sample 4	1.6	1.26	85.32	11.0	1.0	coal	54

sample	$M_t/\%$	$M_{ad}/\%$	$A_d/\%$	$V_{ad}/\%$	$Q_{net}/MJ/kg$	results evaluation	HGI
sample 3				4	6	gangue	
sample 4	2.8	1.98	32.18	29.72	20.12	large coal	71

When the coal was unloaded for 17 days, the iron mesh was sifted in the coal unloading grid of the train, and the large-size material (greater than 100 mm) in the coal was blocked from entering the coal conveying system by manually reducing the size of the sieve hole, with the large material on the sieve cleaned manually. The coal block after the screening had been washed by the rainwater, with part of the grayish white coal gangue. The gray block was selected on site (particle size is 100-200mm), and it is difficult to break the crushing process and needs to be struck by the multiple hammers to crack, which shows that the texture is very hard, indicating that there is a harder coal gangue in the A coal.

According to the analysis of coal quality and coal storage of A coal, the coal quality of A coal fluctuates greatly and the uniformity of particle size distribution is poor. Meanwhile, there is actually a coal gangue with hard texture and hard to grind in A coal pile.

4 Analysis of the coal conveying system and the boiler operation impact

4.1 Analysis of the coal conveying system impact

Table 3 shows the statistical table of the damage of the screening equipment when conveying A coal. During the coal loading process, the coarse crushing machine and the fine screening machine on the coal conveying system cause a certain degree of damage.

Table 3. the statistical table of the damage of the screening equipment when conveying A coal

time	unit	coarse crusher hammer	Fine screen machine	Fine crusher hammer
1d	number	0	1	1
5d	number	0	1	2

The operation history data of the fine crusher B were retrieved on the 5d. Table 4 shows the motor current and vibration parameters (5d) when the fine crusher B trips. During the trip of the fine crusher B, the vibration value of the left bearing (upper) of the fine crusher B reached 25mm/s. In the case of the normal clearance, the cause of the large vibration of the fine crusher is that some of the hammers are damaged, causing the rotor to lose balance. The statistical data (5d) of the damage of the hammer of the fine crusher in Table 3 are consistent with the operational history data of the large vibration trip of the fine crusher B on the same day.

As explained above, in the process of coal conveying, the hard coal gangue in A coal can have adverse effects on the equipment such as the coarse crusher and the fine sieve machine. In severe cases, the hammer of the coal crusher and the vibrating screen machine can be damaged.

Table 4. the motor current and vibration parameters (5d) when the fine crusher B trips

parameter	unit	value	normal value
fine crusher B motor current	A	1.86	30-40
fine crusher B left bearing vibration (top)	mm/s	25	5-10
fine crusher B right bearing vibration (top)	mm/s	11.83	5-10

4.2 Analysis of the boiler operation impact

The time period of the boiler to burn A coal was 1-8d. During this period, there was no other coal for the first time in the boiler. Compared the main operating data of the boiler before and after burning A coal, it was found that after burning A coal, the differential pressure of the furnace, and the difference value between the furnace plenum pressure and the bed pressure^[16] show obvious abnormality.

Figure 2 shows the change charts of the differential pressure of the furnace, and the difference value between the furnace plenum pressure and the bed pressure on the right side before and after burning A coal. The time for burning A coal in the boiler was about 8d. After burning A coal for a period of time, it can be seen from the figure that the differential pressure of the furnace is significantly reduced, from 0.9kPa (burning A coal, 1d) to 0.6kPa (11d before the unit shutdown). It is illustrated that while the differential pressure of the furnace is reduced, the concentration of suspended material in the upper part of the boiler is reduced, and the circulating ash volume is reduced, and the upper part of the furnace is reduced. The difference value between the furnace plenum pressure and the bed pressure on the right side is significantly increased, from 4.9 kPa (burning A coal, 1d) to 7.2 kPa (11d before the unit shutdown). So it is indicated that large particles deposited at the bottom of the bed, hood wear speeding up, the power consumption rate of the primary fan increase, and the fluidization quality decreases, which has an impact on the safe and stable operation of the boiler.

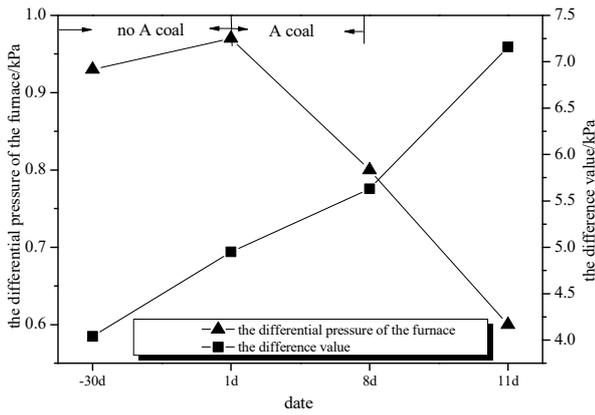


Fig. 2. The change charts of the differential pressure of the furnace, and the difference value between the furnace plenum pressure and the bed pressure on the right side

Figure 3 shows the boiler hood damage diagram. And it was found that the hood was damaged a lot in the process of boiler shutdown inspection. The total number of burned hoods is 750 (the total number of hoods is 2234) and the damage ratio is 33.5%. In the normal maintenance period of the boiler (by 100d operation period), the burned hood is less than 150.



Fig. 2. The boiler hood damage diagram

Table 5 shows the statistics of the blockage of the slag discharge pipe of the boiler after burning A coal. The boiler had frequent clogging problems after burning A coal. A total of 6 blocked pipes occurred and the cold slag block is blocked for up to 13 hours.

Table 5. the statistics of the blockage of the slag discharge pipe of the boiler after burning A coal.

number	time	slag cooler	blocking time /h
1	2d	#2	3
2	4d	#2	5
3	7d	#1	13
4	8d	#4	2
5	10d	#1	2.5
6	11d	#4	1

5 Suggestions

In view of the problem that the boiler has a large proportion of the hood, the amount of circulating ash is

reduced, the large particles at the bottom of the bed are deposited, and the slag discharging pipe is frequently blocked after burning the A coal, the boiler is adversely affected, and it is recommended to screen A coal. After that, it is burned into the furnace to ensure safe and stable operation of the boiler.

(2) Based on continued combustion without treatment of A coal, the suggestions are as follows:

① During the process of conveying coal blending, the blending ratio of A coal should be controlled. The proportion of blending should be gradually changed from small to large, and the blending ratio should not be too high. In the process of crushing the blended coal, the current and vibration of the coarse/fine crusher should be strictly monitored. If the parameters are found to be abnormal, the A coal blending should be reduced or stopped.

② When transporting A coal separately through the crushing and screening system, it is recommended to try to reduce the output operation of the coal conveying system, which is beneficial to reduce the discharge granularity after the crushing of A coal. After the implementation of this measure, the operation of the boiler is closely monitored. When this measure is implemented, we should comprehensively consider the coal consumption unit consumption index.

(3) When the boiler is mixed with A coal, the boiler slag is reinforced, the boiler operating parameters are closely monitored, and the parameters such as the furnace differential pressure and differential pressure of the bed are mainly concerned. When there is obvious abnormality, the A coal should be reduced or stopped immediately to ensure the safety of the boiler stable operation.

6 Conclusions

Through the on-site inspection, the coal quality data of each batch of A coal, the storage situation of the coal yard, the impact on the coal handling system and the operation of the boiler were analyzed, and the following conclusions were obtained.

(1) According to the analysis of coal quality and coal storage of A coal, the coal quality of A coal fluctuates greatly and the uniformity of particle size distribution is poor. Meanwhile there is actually a coal gangue with hard texture and hard to grind in A coal pile.

(2) The hard coal gangue in A coal can have adverse effects on the equipment such as the coarse crusher and the fine sieve machine. In severe cases, the hammer of the coal crusher and the vibrating screen machine can be damaged.

(3) After burning A coal for a period of time, it can be seen from the figure that the differential pressure of the furnace is significantly reduced. It is illustrated that the concentration of suspended material in the upper part of the boiler is reduced, and the circulating ash volume is reduced, and the upper part of the furnace is reduced. The difference value between

the furnace plenum pressure and the bed pressure on the right side is significantly increased. So it is indicated that large particles deposited at the bottom of the bed, hood wear speeding up, the power consumption rate of the primary fan increase, and the fluidization quality decreases, which has an impact on the safe and stable operation of the boiler.

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