Analysis and Countermeasures for Fly-ash Feature from Zhungeer Coal with Electrostatic Precipitation

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Abstract: Zhungeer coal for ESP is a extremely difficult one with low sulfur content (0.43%), low inherent moisture (≯2%), high ash (31.7%), over-high aluminum (Al_2O_3: 51.72%), middle-high silicon (SiO_2: 40.63%), low iron (Fe_2O_3: 1.38%), low sodium (Na_2O: 0.02%) ,and low potassium (K_2O: 0.43%) etc. This kind of coal can, after firing in boiler, result in difficult dust conditions with the light specific gravity, fine particles and high resistivity, but it belongs to "green coal" due to low sulfur content and has a great number of reserves, and for the future, many power stations will still use it. The present paper, through the analysis of physical and chemical for this coal and contrasting the practice experiences used for industries, proposes requirement of design electrotype and other eligible corresponding measures.

Keywords: Zhungeer coal, Electrostatic precipitator, Collecting efficiency

1 INTRODUCTION

There are an great number of reserves in the Zhungeer area, 1980's in last century, a oversize type air open coal mine was built by government and the coal are provided to east China, south China and Inner Mongolia as well as its around areas as dynamical coal for power plants. With the development of power stations rapidly in China, the more and more Zhungeer coal to be used for power plants. Because the characteristic of this coal goes against the collecting dusts of ESPs, new problems that could not be avoided are bought to some power plants whose fire this kind of coal. Therefore, solving this problems of a sort of coal are not only the things in China, but it proposes a question for many countries firing the difficult coal, namely, the relationship of the coals and emissions.

Almost 10 ESPs have been provided by our enterprise to the generating units that fire the Zhungeer coal, so we have a lot of lessons and experiences and did many works for this, such as the Characteristic analysis of physical and chemical for dust sampling, the reduction of boiler load, the research of different flue gas flow, the changing situation of collecting efficiency under different conditions of SCA and the control mode of changing electricity as well as using the simple pulse power supplying method to explore the corresponding relationship of collecting efficiency etc.

2 CHARACTERISTIC OF ASH RROM ZHUNGEER COAL

The chemical component analysis of dusts taken samples from internal ESP in a generation unit with 300MW of a certain power plant was implemented, among which, SiO_2 content is 40.63%, Al_2O_3 content 51.72% and Fe_2O_3 1.38%, the sum of three items exceeds 93.73%, nevertheless, so little content of Na_2O, LiO and K_2O is infrequence in coal fired history, especially the Al_2O_3 content up to 51.72%, also infer-quence. If taking into consideration of other disadvantages factors of low sulfur content (0.43%), low moisture(1.91%) and high ash(31.7%), we can see that the dusts removing conditions for ESP is quite difficulty.

The analysis shows that the most of dust samples in the shape and look is some non-crystal melting substances with reticulation hollow, very fine and light, and after falling to pieces, the thin hulls and agglomeration body of different thickness and some spherical particulates can formed. This kind of dusts have a big specific surface area and high refraction. The chemical components of fly-ash consist of oxide, and actually are many shaped chemical combination body with silicate, silicon and illuminate and little sulfate, carbonate and other oxides. In general, we take the format of oxide as analysis basis. These resultants exist in coal mainly in the form of crystal salt substance or non-crystal one and just a little of them exist in the form of crystal oxide. The test analysis indicate that The most of aluminum element in the Zhungeer coal exists in the form of compound, namely Al_2O_3 , but there are no the crystal substance of Al_2O_3 in non- Zhungeer coal with little content of Al_2O_3, it just exists in the form of SiO_2. The density of crystal Al_2O_3 is higher, 3.97% g/cm^3, it advantaged to collecting the dusts. And the compound of Si element, especially dissociative SiO_2 are very little, and the most of Al_2O_3 and SiO_2 exist in the form of non-crystal substance, their particle sizes are very fine and the crystal structure incomplete. The pure Al_2O_3 is a excellent isolation material but the resistivity of pure SiO_2 higher as well, because it can eliminate the action of Na_2O, so it difficult to be charged and collected, in the same time, it sensitive to dust re-entrainment. Yet, some component of dusts are seem to represent the certain electric active, which can charge slowly under the conditions of strong field and produce the electric entrainment that is similar to the wood elliptical ball effect.

The property of adherence between dust particles and

liquid calls the soakage. Under the conditions of the same humidity in flue gas, the particles with the good soakage property are easy to adhere each other and coagulation, it is of advantage for collecting over fine dusts. When Al_2O_3 content in dusts is increase, it can make the soakage of dusts increasable, reduce the dry degree of dusts, promote the adherence and coagulation for dusts and cut down the re-entrainment, this is favor to the ESPs. But, the SiO2 is opposite just, increase of its content will decrease the soakage of dusts and is adverse to collecting the dusts. It should be pointed out that the chemical component of dusts is one of the reasons of influencing the soakage only, there are many factors may affect the soakage such as around temperature, humidity and pressure etc.

The element Fe in dusts exists in the form of Fe_2O_3 and Fe_3O_4. The Fe_3O_4, commonly accounting for over 2/3 in the total of iron oxide has the intensive action to the conduction of alkali metal ions, it can greatly reduce the fly-ash resistivity.

The resistivities of fly-ash which were measured by BDL testing meter for dusts from ductwork in site are $5.88\times 10^{12}\Omega\cdot$cm-$6.57\times10^{12}\Omega\cdot$cm. For the operation conditions of site, this kind of high values is just very few.

3 CONDITIONS OF RELATIVE TESTS AND ENGINEERING APPLICATION

3.1 Test Situation of Different Field's Gas Velocity and SCA

We, through reducing evaporation volume from boiler and lowering gas velocity, seek the corresponding relationship that the collecting efficiency is decrease and the SCA increase with the reduction of gas flow from an ESP of boiler with 50 MW capacity in a certain power plant.

It is not possible to reduce the gas flow to the necessary level, due to the difficulty of adjusting the load, during the actual test, yet the law reflected by test is the definite, number's relationship the stable and suitable for the typical formula of collecting efficiency. We find out that the collecting efficiency of ESP is to greatly decrease with the increase of field's gas velocity at the premise of such dust feature and flue gas conditions, it is also said that for the same SCA, the higher collecting efficiency will be obtained in the low gas velocity condition of field within the limited collecting efficiency range, and the maximum SCA, during tests, just hit the $108 m^2.s/m^2$.

3.2 Application Example of Project at a Generating Unit with 330 MW

We, on the base of further understanding the fly-ash feature from Zhungeer coal with electrostatic precipitation, took several measures for ESP design of a boiler with 330 MW in a certain power station to overcome this kind of difficult coal and meet the environment standard, which the measures are to increase the collecting area (unit gas volume area: 146.4 $m^2\cdot s/m^2$), to decrease the gas velocity (0.72 m/s) and to add the numbers of electric fields (up to 5 fields). Meanwhile, some other method were taken, for example the spikes or tooth of wires with different height were used in field 1, 2 and 3 and each field for field 4 and 5 was divided into 2 bus sections and the technology of fishbone wires plus auxiliary electrodes with good power supply performance adopted for ESP. In order to improve the rapping cleaning performance and reduce the mechanical failure, some measures of unit assembling shafts and integral hammers also adopted. Because of above measures, the performance of ESP including the reduction of re-entrainment was improved and emission met the requirement. Such big improving measures taken for an ESP to raise the performance is not only a few in China, but also in world.

3.3 Effect of Operation Mode

The Zhungeer coal are fired in an generating unit with 330 MW of a certain power plant and the relationship between collecting efficiency of ESP and electric power is obvious positive phase one, according to data from power supply unit and opacity meter. But, the spark discharges are easy to be produced under the conditions of lower secondary voltage and higher secondary current. Through the observation of control mode for field B12 that the spare track was changed to the makeshift pulse adjustor, we found that this sort of mode can increase the secondary voltage of over 5 kV and decrease the secondary current of 20%.To quantitatively measure the effect of raising collecting efficiency using the simplified pulse energization mode, a chamber with 7 bus sections was selected and all adjustors were changed over to the makeshift pulse power supply mode under the condition of full load and smooth operation for boiler. Then we carried out the contrast tests for before and after changes, and found that the collecting efficiency of ESP increases from 99.13% to 99.31%.

It can be seen that although the re-entrainment for such dusts are obvious due to the electric entrainment similar to wood ellipse ball effect and the dust characteristics of fine size, small density and easy escaping, this re-entrainment can be solved in the certain limited range through further improve the electric control and mode of power supply, and the collecting efficiency of ESP can be further increased.

3.4 Influence of Boiler's Firing Mode

The combustion of boiler is a complicated process, different coal, different combusting equipments and modes and different auxiliary facilities as well as different boiler operation modes and adjustment have a direct effect for the firing efficiency, and the results said above will be cause some problems which directly influence the dust characteristic, flue gas performance and further influence the collecting efficiency, such as the formation of ultrafine particulates caused by a high flame temperature, the high temperature of boiler and O_2 content deciding whether SO_3 is formed or not and the unburnt particles placing a premium on re-combustion and re-entrainment in field.

After obtaining the initial successful experiences from a ESP of boiler with 330MW for a certain power plant, we provided two ESPs for the CFB boilers with 2×135 MW of another power plant. For this ESP, the design gas velocity is 0.77 m/s, SCA is 117.79 $m^2\cdot$ m^2/s, wire type is RS type and

new type saw, spacing of pole to pole in first three fields is 410mm and last field 490 mm. Test value shows that the efficiency (98.5% is lower than design value (99.75%) and the Al_2O_3 content reaches 46.3%. We found by analyzing the reasons that with the exception of high gas temperature (design temperature 137 □, actual 160 □), large gas volume and high gas velocity, the most important reason is that the dusts characteristic has been changed due to different combustion mode of boiler. The test result of particle sizes indicate that accumulation percentage of particle size (limestone was not used during efficiency test period) under 5 μm is large, accounting for 46.3%, see Fig. 1.

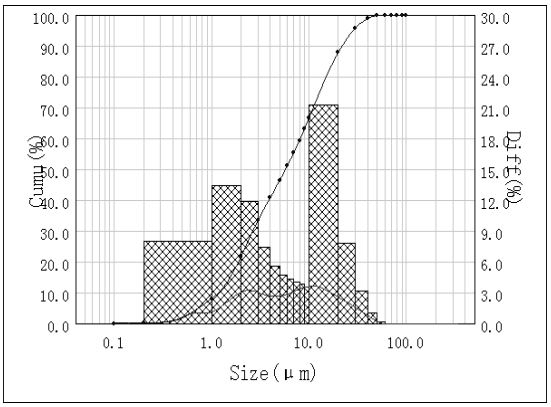

Fig. 1 Granularmetric analysis to fly-ash in CFB boiler

CFB boiler has a good environmental performance, fuel adaptability and load accommodating ability. The dusts produced from CFB has the characteristics of high resistivity, large concentration and big granularity. It is researched that the contents of SiO_2, Al_2O_3, TfeO, CaO, MgO in fly-ash generated by CFB are regularly changed with the particle granularities. The content of SiO_2 in dusts is gradually reduced with the reduction of particle granularities, and that the contents of Al_2O_3, TfeO, Cao, MgO are gradually increased with the reduction of particle granularities. Element Fe in fly-ash from CFB exists mainly in the form of Fe_2O_3, and that element Fe in pulverized coal furnace exists in form of Fe_3O_4. It can be seen that because of misunderstanding the fly-ash characteristics of CFB boiler and copying the experience from pulverized coal furnace, the collecting efficiency of ESP could not receive the guarantee under the condition of difficult coal.

4 CONCLUSIONS

For such a difficult coal similar to Zhungeer coal, if using the corresponding methods, the problems of dust collecting difficulty can be solved as well.

When a power station uses the Zhungeer coal, the dust resistivity will be over-high caused by large contents of Si, Al and Fe, and collecting efficiency will become difficulty. Yet, if certain of active components are contained in the physical phase structure, ESP can maintain the normal operation.

Fly-ashes with high aluminum have a less adherence force, is sensitive to field's gas velocity and easy of producing the re-entrainment. Therefore, when capturing this sort of special property's dusts generated by difficult coal, the gas velocity in the field should be much low (around 0.7 m/s) and the SCA (around 150 m^2. s/m^2) much high, comparing to the general industries in the matter of ESP electrotype.

The electric operation mode of ESP should be in pursuit of high field's strength and low current so as to increase the average voltage and power, things like this, the collecting efficiency can be raised. If using the simplified pulse energization mode, the performance of ESP also has a certain improvement.

When the combustion mode of boiler induces a change of dust characteristic, the serious analysis should be implemented for the particle granularities and physical phase structure. It has been found that when firing Zhungeer coal for CFB boiler, it is very difficulty for ESP to hit the emission standards, in this event, if choosing the hybrid unit with ESP and bag-filter is chosen, the problems can be solved. This sort of unit can learn from other's strong points to offset ESP's weakness, on hand, the advantages of ESP, such as high efficiency, low resistance and energy, operation safety and reliability as well as maintenance convenience etc., can be fully exerted, on the other hand, the bag filter's merits also can be exerted, such as non-insensitivity for different coals, high collecting efficiency for ultra-fine particulates etc., so it is a up-and-coming unit for power plants.

In despite of how many different coals are adopted by power stations or what sort of the components these coal are , the important things for ESP manufacturers are to understand the coal's information and to communicate to the users, if so, manufacturers can predominate a large flexibility and initiative for choosing ESPs**.**

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