Cause Analysis of Congested Pulverized Coal Dropping of Pulverized Coal Feeder in Storage Pulverizing System and Solutions

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Abstract: The newly built unit in certain power generation company adopts storage pulverizing system and 16 sets impeller coal feeder. The pulverized coal feeders suffered unstable feeding frequently during infrastructure debugging, leading to large fluctuation of furnace negative pressure, steam temperature and load, and affecting safe and stable operation of the unit. This paper deeply analyzes the causes of congested feeding of pulverized coal feeder, formulates corresponding countermeasures from aspects of cleaning, installation and operation adjustment of pulverizing system, and guarantees stable operation of the unit through optimization logics and operation method. This paper provides references for actual operation and solution of similar problems in power plants.

1. Introduction
At present, due to large difference between actual combustion coal quality and designed coal quality in many coal-fired power plants in China, more fire-coal sources, and great change in coal quality, many newly built thermal power units select the storage pulverizing system considering coal quality and combustion stability; however, the pulverized coal feeders suffered many problems such as feeding interruption and blasting during infrastructure and debugging, leading to unstable combustion, large fluctuation of negative pressure, steam temperature, steam pressure and load and even flameout, and bringing large loopholes for safe operation of the unit. Therefore, it is necessary to study and solve unstable feeding problem of the pulverized coal feeder and guarantee safe and economical operation of the unit.

2. Brief introduction to the unit and main parameters
The boiler is a DG1150/18.3-II12 subcritical parameter drum boiler; the boiler is the Type II boiler with tangential firing mode, primary intermediate reheating, single furnace balanced ventilation, dry ash extraction, semi-outdoor layout and all-steel structure. The boiler adopts bin pulverizing system. Each set of boiler sets three MTZ3872 drum type ball pulverizers, and there is one burner corresponding to each pulverizer. Totally 16 burners are distributed on four corners of the boiler in four layers. The cold air from the primary fan is heated by the primary air bin of three-bin air pre-heater, and sent to pulverized coal pipe through the primary air duct. The cold air from the blower is heated in the secondary air bin of the three-bin air pre-heater, and partly mixed with cold air entered
from the cold air valve on the pipe section to enter pulverizer as temperature regulating air; the air-pulverized coal mixed flow from the pulverizer passes through coarse pulverized coal separator and fine pulverized coal separator; the air after separation is sent to the furnace through pulverized coal exhaust fan as tertiary air; the pulverized coal entering the bin passes through pulverized coal feeder, is mixed with primary air and injected to furnace through pulverized coal pipeline and burner. Main designed technical parameters of the pulverized coal feeder can be seen in Table 1,

| Item                  | Unit | Data  |
|-----------------------|------|-------|
| Model                 | -    | NGF-15|
| Rated output          | t/h  | 5-15  |
| Pulverized coal density | t/m³ | 0.65 |
| Impeller diameter     | mm   | 386   |
| Impeller tooth number | -    | 12    |
| Spindle speed         | r/min| 21-81 |
| Transmission ratio    | -    | 13.5  |

3. Judgment principle of the pulverized coal feeder’s feeding status

The congested feeding of the pulverized coal feeder will lead to sudden decrease of feeding amount under normal speed. According to the mechanism of pulverized coal and air mixing, after the feeding is interrupted, the temperature of mixed air and pulverized coal rises rapidly, pulverized coal concentration drops and air speed increases. Install temperature measurement points to the primary air duct, pulverized coal pipe, and primary air duct after air and pulverized coal are mixed to measure the temperature of primary air, pulverized coal and the mixture. Then, calculate temperature of the mixture and pulverized coal concentration by the mass conservation and energy conservation equation of the fluid. Install differential pressure transducer to the primary air duct; when the fluid passes through, the differential pressure signal is generated; the primary air speed may be acquired through verification by air status equation.

According to energy and mass conservation,

\[ Q_1(t_1 - t)c_1 = Q_2(t - t_2)c_2 \]  
\[ t = \frac{c_1Q_1t_1 + c_2Q_2t_2}{c_1Q_1 + c_2Q_2} \]

In formula (1) and (2),

\[ Q_1 \text{ and } Q_2 \] are respectively pulverized coal pipe air and pulverized coal mass flow rate (t/h);  
\[ c_1 \text{ and } c_2 \] are respectively the pulverized coal pipe air volume and average specific heat of the pulverized coal (KJ/Kg);  
\[ t, t_1 \text{ and } t_2 \] are respectively the temperature of mixture, air and pulverized coal before mixing (°C), \[ t_1 \text{ and } t_2 \] may be feeding hot air temperature and pulverized coal bin temperature after air pre-heater is used.

Calculation formula of pulverized coal concentration \( \mu \) is as follows:

\[ \mu = \frac{Q_2}{Q_1} = \frac{c_1(t_1 - t)}{c_1(t_1 - t)} \]

In formula (3),  
\[ \mu \]: content of pulverized coal in unit air (kg/kg);  
\[ V = K \sqrt{\frac{2\Delta P}{\rho}} \]  

In the formula,  
\[ \Delta P \]: Differential pressure of differential pressure transducer (Pa);
\( \rho \): hot air density (kg/m\(^3\));

K: flow rate calibration coefficient;

Suppose the speed and output of the pulverized coal feeder is linear, according to Table 1, the relation function between the feeder output \( Q_2 \) and feeder speed \( \nu \) shall be:

\[
Q_2 = 10 \left( \frac{\nu - 283.5}{13.5(81 - 21)} \right) + 5
\]

(5)

According to Formula (2), when the feeder speed is stable and assuming specific heat remains unchanged, \( t \to t_1, Q_2 \to 0, \mu \to 0 \); thus, judge whether feeding is smooth or interrupted; meanwhile, since the flow resistance in the pipe is smaller, the air speed will increase obviously.

4. Judgment of the pulverized coal feeder’s feeding status and cause analysis

(1) If the temperature of pulverized coal at the outlet of the pulverizer is low, the water content in pulverized coal will increase correspondingly, and pulverized coal is easy to cake; while with the pulverized coal temperature in the bin becomes lower, the pulverized coal flow rate will be dropped further, pulverized coal is easy to be clogged so that the feeding is congested or interrupted.

(2) When the boiler load is low or in order to improve economical efficiency of unit, the inlet/outlet temperature of the pulverizer is controlled through recycling damper, resulting in continuous circulation of water content separated out from raw coal in the pulverizing system; the hot air is highly humid, so although outlet temperature may be improved properly, the pulverized coal is easy to become damp after the temperature is lowered, leading to congested feeding or no feeding of the feeder.

(3) The feeding may be congested if the bin level is low or pulverized coal level is not even. The pulverized coal is in the air-coal mixture state when entering into the bin; pulverized coal sedimentation takes time, and the weight of pulverized coal in the up area is required to lay solidly the pulverized coal at the inlet of the feeder. If the pulverized coal level is low, the air entering the feeder will be more, and correspondingly the pulverized coal amount will be reduced; while such state is a non-stable state, and feeding amount is not even so that the air-pulverized coal mixture concentration in the primary air duct is fluctuated. That is the common internal disturbance of the boiler.

(4) If the bin is not cleaned before first commissioning or the upper area of the bin is not sealed, debris may enter the bin and block the inlet of the feeder so that the feeding is intermittent and even the feeder is fully blocked. That is an important reason for congested feeding or feeding interruption. Meanwhile, pay attention to cleaning of wood chip separator. Due to structural principles of the device, the problems such as bushing leakage, blocking or gearbox leakage of pulverized coal feeder are common.

(5) Due to insufficient experience of operators, the pulverized coal pipe is clogged, and pulverized coal is deposited in pipe and combusted spontaneously, leading to high mixture level. It may be taken for congested feeding of the pulverized coal feeder.

(6) The pulverized coals are coarse-grained, which is an important factor affecting feeding of the pulverized coal feeder. The steel ball amount, proportion of large and small balls and operating parameters may affect fineness of pulverized coal; the coarse pulverized coal makes worse mobility; water content in pulverized coal is difficult to be separated out, and possibility of feeding interruption of feeder may be added.

5. Countermeasures for instable feeding and combustion optimization of pulverized coal feeder

(1) Check air-tightness of pulverizing system, including all explosion doors, pulverized coal conveyer, standard steel rope holes, air lock and pin of the system; seal the leaking area to guarantee air-tightness of bin.

(2) Adjust temperature of the mixture at the outlet of the pulverizer to 90–105°C, maintain the pulverizer inlet pressure at -200Pa–400Pa, and try to reduce the openness of the recirculation when cold and hot damper meets air temperature adjustment requirements.
(3) Maintain the bin level above 2m during normal operation; empty the bin if the unit is shut down for over 3 days; reduce bin level every 2~3 days to avoid pulverized coal with worse mobility inside the bin being damp and caked.

(4) Reasonably input feeders according to load of the unit, and avoid losing adjustment allowance due to excessively high speed of the feeder.

(5) When feeder layer is operating, adjust the feeder’s speed offset according to mixture concentration or temperature after mixing in the primary air duct to make consistent output of all feeders. If the automatic adjustment fluctuation is large, switch to manual operation; put oil for combustion where necessary.

(6) Add logic feeder conditions for feeding failure, specifically as follows:

\[
\text{wind speed}>25\text{m/s} \quad \text{AND} \quad \text{Rotational Speed of Powder Feeder}>300\text{rpm} \quad \text{AND} \quad \text{Concentration of air powder mixture}<0.15
\]

Fig. 1

When the feeder fails to feed pulverized coal after judging based on this condition, automatically eliminate the feeding amount of that feeder; when certain feeder stops feeding, automatically add output of the feeders on the same layer to the layer output before feeding interruption, and avoid large disturbance of steam temperature, steam pressure and load.

(7) According to load requirements, start and stop feeders in time to make the feeders within appropriate speed scope; excessively high speed is one of the common reasons for frequent feeding failure. When the speed is fast, the linearity of the feeder becomes worse, and feeding interruption disturbs and affects combustion seriously.

(8) Control suitable pulverized coal fineness to add mobility by adding small diameter steel balls; close the openness of coarse pulverized coal separator baffle; adjust negative pressure at outlet of pulverizer at -200~-300Pa; adjust pressure at inlet of exhaust fan to match with parameters such as negative pressure of pulverizer inlet, and inlet and outlet differential pressure.

6. Summary

(1) The quality of pulverized coal in bin directly affects stable feeding of pulverized coal feeder. The temperature, fineness and water content of pulverized coal in pulverizer are key factors measuring quality of the pulverized coal, and are crucial to economical and safe operation of the unit as well. An important approach to make combustion stability measures is to judge operating status of feeders.

(2) This paper analyzes changes in relevant parameters when the feeder’s feeding is congested through process mechanism; operators may directly judge operating situations of the pulverized coal feeder through thermal logic and further adopt corresponding measures.

(3) In the installation stage, the direct approaches controlling feeder inlet blocking are to clean inside area of the bin, control debris from being entered and guarantee air-tightness of the pulverizing system. Clean installation is an effective measure to avoid abnormal feeding of the feeder.

(4) This paper analyzes common causes for congested feeding of feeders from several aspects including operating parameters and adjustment, reduces frequency of congested feeding to a great degree with targeted measures, and guarantees safe and stable operation of unit in infrastructure and debugging stage through practices.

(5) This paper anticipates internal disturbance generated by feeding failure of the feeders according to changes in thermal physical process parameters after feeding is interrupted; the optimization of thermal logic may effectively reduce unstable combustion caused by congested feeding and greatly guarantee stable operation of the unit.
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