Combustion Adjustment in Initial Startup Stage of 660MW Supercritical Fossil Power Unit

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Abstract: In order to better improve economical efficiency, the newly built supercritical units mostly adopt more fuel-saving ignition mode, but in the initial startup stage, the parameters of unit and boiler are not compatible. This paper carries out study and analysis on parameters in the initial startup stage, and optimizes all parameters by adjusting startup feed-water quantity, fuel quantity, air volume and ratio for several times. With favorable effect, this paper may be used as good reference for other similar units.

1. Introduction
Due to remarkable economical and environmental protection effect of supercritical/ultra supercritical DC unit, the supercritical/ultra supercritical fossil power units are developing rapidly at home and abroad. To get better economical efficiency, the traditional oil gun ignition mode could not adapt to demands of the owner; the energy-saving technologies such as plasma, less oil (tiny oil) ignition have been applied universally to the newly built units.

The change in ignition mode makes combustion characteristics of the unit in startup ignition and medium and low load stage changed greatly, and solves a series of problems such as high steam temperature, insufficient drop water, and over-temperature of local heating area in initial startup stage. This paper applies adjustment for combustion optimization aiming at aforesaid problems and in combination with certain factory.

2. Brief introduction to the unit
The 2×660MW unit boiler in certain project is a SG-2150/25.4-M976 supercritical parameter variable-pressure operation DC boiler manufactured by Shanghai Boiler Works Co., Ltd.; 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. It adopts built-in start-up separation system without circulating pump; the startup water will be pumped to water tank at the bottom of steam turbine exhaust equipment by the drainage pump through expansion in the air. The boiler adopts positive-pressure direct-blow pulverizing system with cooling primary fan; each boiler sets six Shanghai heavy units. In this project, the four burners on the lower layer of pulverizer A are changed to plasma burners. Moreover, relevant auxiliary system is designed to realize cold dry startup of the boiler.
3. Boiler characteristic analysis

The control over feed-water temperature and main reheating steam temperature during startup of the supercritical boiler has always been the common technical problems during the commissioning stage; in addition, when the unit adopts cold start, the problem of startup parameters control will be more prominent as affected by factors such as auxiliary steam supply amount, startup system design characteristics and ignition mode. The following aspects are included in specific:

1) During cold start process, the auxiliary steam supply amount is insufficient, leading to lower feed water temperature and less boiler steam.

2) In initial stage of design, the deaerator during unit operation may be of over pressure. During design optimization, the pipeline from the steam trap to the deaerator of boiler startup separator in original boiler work’s design is cancelled, and the drain heat of startup separator could not be recovered.

3) The minimum startup flow (usually no smaller than 30% BMCR) provided by the boiler manufacturer is higher; as restricted by auxiliary steam amount and affected by heat loss recovered from steam trap after the deaerator is cancelled, the water temperature at inlet of economizer may not be high, and steam evaporation stage is in the late section. When maintaining fuel load during the startup process, the larger the feed water flow is and the lower the feed water temperature is, the lower the boiler steam generation will be, and the more difficult the overheating and reheating steam temperature will be.

4) The unit adopts plasma ignition mode. The flame radiation characteristics are greatly different from that of traditional fuel startup mode. The pulverized coal is delayed to ignite, flame center moves upward, and furnace heat absorption capacity is small, resulting in higher heat absorption ratio of super-heater and re-heater system and higher steam temperature.

5) In the initial startup stage of the unit, the main steam directly enters re-heater without acting through high pressure cylinder. Thus, the problems of cold reheat piping overheating and higher reheating steam temperature are more prominent.

4. Strategies and combustion optimization and adjustment

After analyzing prominent problems affecting the startup parameters control in aforesaid aspects, the following solutions may be adopted:

1) Try to improve auxiliary steam supply pressure and meanwhile reduce unnecessary auxiliary steam users; supply temporary boiler or soot blower steam sources to air pre-heater for continuously blowing, as shown in Fig.1; meanwhile, remove plasma air heater and close air heater steam supply valve when the hot primary air reaches certain temperature after boiler ignition to guarantee air volume of deaerator.

2) Consult with the boiler manufacturer to properly reduce minimum startup feed water flow; closely monitor wall temperature of pipe adjacent to water wall helix tube outlet and vertical pipeline section outlet during ignition.

3) Aiming at plasma ignition or low oil ignition mode, shorten ignition point of pulverized coal, lower flame center, add heat absorption amount on the evaporation section, reduce heat absorption amount on convection section and effectively control steam temperature by means of lowering burner angle, properly lowering pulverized coal fineness, maintaining suitable excessive air coefficient and improving primary air temperature.

4) Input condensate water fine processing system and recover some of boiler water as early as possible when iron content in steam separator is stably lower than 1000μg/L during hot flushing.

5) In order to increase flow of cooling water, adjust by enlarging pressure difference between main feed water and boiler side. However, the characteristics of main feed water bypass adjusting valve and cooling water adjusting valve of the official system, particularly special requirements for valve pressure difference and flow, shall be taken into account.
5. Optimization results and analysis

Based on sufficient study on unit characteristics and clarified optimization direction, optimization and adjustment is carried out by virtue of unit startup process. After twice optimizations, each parameter becomes reasonable, safe and notably economical. Main parameters and changes before and after change can be seen in Table 1, Table 2 and Table 3.

Table 1 Main parameters during unit startup process optimization

| Item                  | Unit | Design | Optimization 1 | Optimization 2 |
|-----------------------|------|--------|----------------|----------------|
| Feed water flow       | t/h  | 645    | 530            | 489            |
| Feed water temperature| ‘C   | 110    | 80             | 108            |
| Fuel amount           | t/h  | 63     | 32             | 32             |
| Total air volume      | t/h  | 745    | 1003           | 757            |
| Feed water flow       | t/h  | 645    | 530            | 489            |
| Feed water temperature| ‘C   | 110    | 80             | 108            |
| Fuel amount           | t/h  | 63     | 32             | 32             |
| Total air volume      | t/h  | 745    | 1003           | 757            |
| Main steam temperature| ‘C   | 410    | 450            | 388            |
| Main steam pressure   | MPa  | 8. 9   | 8. 0           | 5. 2           |
| Reheating steam       | ‘C   | 430    | 461            | 421            |
| Reheating steam       | MPa  | 0. 4~1. 0 | 1. 1       | 0. 4           |
| Overheating cooling   | t/h  | 0      | 21+17+7.8+15. 2 | 14+17+43+38   |
| water amount          | t/h  | 0      | 8. 2+10        | 4. 9           |
| Air box differential  | Pa   | 380    | 472            | 358            |
| pressure              |      |        |                |                |
| Burner angle position | %    | 50     | 20             | 20             |
| SOFA angle position   | %    | 50     | 0              | 45             |
# Table 2 Burner damper opening optimization

| Air box/furnace differential pressure | Pa | Design | Optimization 1 | Optimization 2 |
|--------------------------------------|----|--------|----------------|----------------|
| Secondary air damper position, AA    | %  | Layer A fuel function | 50 | 30 |
| Secondary air damper position, A     | %  | Corresponding layer fuel function | 25 | 10 |
| Secondary air damper position, A2    | %  | Air box differential pressure | 30 | 10 |
| Secondary air damper position, AB    | %  | Air box differential pressure | 30 | 10 |
| Secondary air damper position, B     | %  | Corresponding layer fuel function | 30 | 0 |
| Secondary air damper position, B2    | %  | Air box differential pressure | 25 | 5 |
| Secondary air damper position, BC    | %  | Air box differential pressure | 30 | 0 |
| Secondary air damper position, C     | %  | Corresponding layer fuel function | 15 | 0 |
| Secondary air damper position, C2    | %  | Air box differential pressure | 0 | 0 |
| Secondary air damper position, CD    | %  | Air box differential pressure | 0 | 0 |
| Secondary air damper position, D     | %  | Corresponding layer fuel function | 15 | 5 |
| Secondary air damper position, D2    | %  | Air box differential pressure | 0 | 0 |
| Secondary air damper position, DE    | %  | Air box differential pressure | 0 | 5 |
| Secondary air damper position, E     | %  | Corresponding layer fuel function | 15 | 5 |
| Secondary air damper position, E2    | %  | Air box differential pressure | 0 | 0 |
| Secondary air damper position, EF    | %  | Air box differential pressure | 0 | 0 |
| Secondary air damper position, F     | %  | Corresponding layer fuel function | 15 | 0 |
| Secondary air damper position, F2    | %  | Air box differential pressure | 0 | 0 |
| Secondary air damper position, CCOFA | %  | Total air volume function | 0 | 60 |
| Secondary air damper position, CCOFA | %  | Total air volume function | 0 | 60 |
| Secondary air damper position, SOFA1 | %  | Total air volume function | 30 | 0 |
| Secondary air damper position, SOFA2 | %  | Total air volume function | 20 | 0 |
| Secondary air damper position, SOFA3 | %  | Total air volume function | 20 | 0 |
| Secondary air damper position, SOFA4 | %  | Total air volume function | 0 | 0 |
| Secondary air damper position, SOFA5 | %  | Total air volume function | 0 | 0 |
During the optimization and adjustment process 1, adjustment is made according to design parameters. However, the effect of primary adjustment is unsatisfactory, and steam temperature is higher. After careful analysis on the causes, further optimization and adjustment is carried out. Table 1 shows changes between parameters after twice adjustment and design parameters. Practices prove the flushing parameter of optimization and adjustment 2 is satisfactory, and supports startup of similar units. Data in Table 1, Table 2 and Table 3 shows:

1) The startup feed water flow after optimization is 489t/h, which is greatly lower than the designed value 645t/h; it may be further lowered according to water wall temperature and deviation;

2) Comparing fuel amounts before and after twice optimizations, the amount is dropped from 63t/h to 32t/h, and startup fuel amount dropped 50% so that the water wall temperature after starting feed water flow dropped about 30°C; except the maximum wall temperature difference is 2.2°C on 35-45 two adjacent points of rear wall pipe, the wall temperature in other area is largely even; based on judgment according to wall temperature monitoring, the feed water flow could be still lowered, and may be further optimized subsequently.

Table 3 Water wall spiral tube wall temperature

| Pipe No. | First time flushing | After optimization |
|----------|---------------------|--------------------|
|          | Left wall | Rear wall | Right wall | Front wall | Left wall | Rear wall | Right wall | Front wall |
| 1        | 300.7    | 300.1    | 299.7      | 300.2      | 272.1    | 271.1    | 271.4      | 271.4      |
| 5        | 299.3    | 299.9    | 299.4      | 300.7      | 271.3    | 271.5    | 271         | 272.8      |
| 10       | 300.9    | 300.5    | 299.8      | 300.3      | 273      | 272.1    | 271.8      | 272         |
| 15       | 300.4    | 300     | 301.1      | 300.6      | 272.5    | 271.8    | 271.9      | 272.6      |
| 20       | 299.9    | 300.4    | 300.1      | 300.3      | 272.3    | 271.8    | 271.6      | 272.1      |
| 25       | 300.5    | 300.2    | 300.7      | 300.5      | 272.6    | 271.8    | 272        | 272.3      |
| 30       | 299.7    | 300.2    | 299.7      | 301.2      | 272.2    | 272.1    | 271.5      | 273.2      |
| 35       | 300.8    | 300.7    | 300.6      | 300.9      | 272.9    | 272.4    | 272.3      | 272.8      |
| 40       | 299.5    | 299      | 300.7      | 300.5      | 271.2    | 270.4    | 270.4      | 272.6      |
| 45       | 300.5    | 299.2    | 301        | 300.3      | 272.1    | 268.2    | 273.3      | 272.1      |
| 50       | 299.9    | 298.4    | 300.3      | 299.8      | 271.7    | 269.8    | 272.1      | 271.8      |
| 55       | 299.9    | 298.4    | 299.8      | 299.9      | 271.7    | 269.8    | 271.7      | 271.7      |
| 60       | 299.5    | 299.2    | 300.9      | 300.3      | 271.5    | 270.8    | 272.7      | 272.1      |
| 65       | 300.7    | 298.8    | 299.5      | 299.9      | 272.6    | 270      | 271.3      | 271.7      |
| 70       | 300.9    | 298.7    | 300.4      | 301        | 272.8    | 270.4    | 272.1      | 273        |
| 75       | 300.6    | 299.1    | 299.3      | 300.6      | 272.7    | 270.5    | 271.5      | 272.6      |
| 80       | 300.6    | 299.2    | 299.4      | 300.6      | 272.1    | 270.5    | 270.9      | 272.4      |
| 85       | 300.4    | 299.2    | 300.5      | 300.9      | 271.8    | 270.6    | 272.6      | 272.8      |
| 90       | 299.8    | 299.4    | 299.6      | 301.1      | 271.8    | 270.8    | 271.7      | 273        |
| 95       | 299.7    | 299.7    | 300.2      | 300.5      | 271      | 270.2    | 272.4      | 272.4      |
| 100      | 300.5    | 300.2    | 299.9      | 300.7      | 271.5    | 271.8    | 271.8      | 272.7      |
| 105      | 299.8    | 299.4    | 300.4      | 300.3      | 270.9    | 271.4    | 272.7      | 272.1      |
| 110      | 300.1    | 299.7    | 300.3      | 301.1      | 271.8    | 271.6    | 272.4      | 273.1      |
| 112      | 300.3    | 300.4    | 300        | 300.5      | 271.8    | 271.5    | 271.4      | 272.4      |
| Mean value | 300.2    | 299.6    | 300.1      | 300.5      | 272.0    | 271.0    | 272.0      | 272.4      |
| Wall temperature difference | 1.2 | 1.7 | 1.1 | 1.1 | 1.7 | 2.2 | 1.7 | 1.3 |
(3) The main steam temperature and reheating steam temperature after optimization and adjustment are both lower than the designed temperature of the manufacture, guaranteeing service life of the unit;

(4) In the aspect of combustion adjustment, the deviation of air volumes during twice startup process is large; the furnace flame center is lowered after air volume is reduced, in favor of steam temperature control;

(5) The reduction of startup feed water flow increases greatly feed water temperature; under the same combustion density, the steam generation volume is increased, in favor of steam temperature control.

6. Summary

This paper, through carefully analyzing unit characteristics and possible problems, formulates practical and feasible combustion adjustment method and optimization purpose. All parameters of the unit are more reasonable after twice optimizations of startup design parameters, and economical performance and safety are improved obviously.

References
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