Study on an on-line monitoring method for peak shaving capacity of thermal power unit

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Abstract. Relying solely on pure condensing units can not meet the demand for power grid peak shaving, and thermoelectric units must also participate in peak shaving. In view of the dynamic change of peak shaving capacity of thermoelectric units with steam extraction, an on-line monitoring method of thermoelectric units is proposed in this paper. The upper and lower limits of peak shaving capacity of thermoelectric units under different steam extraction are calculated in real time, and the peak shaving capacity of thermoelectric units is evaluated on-line, so as to provide data support for scientific dispatching of power grid.

1. Introduction

With the economic and social development and industrial structure adjustment, the proportion of industrial power consumption decreases, the proportion of municipal and commercial power consumption increases, the peak valley difference of power grid increases, and the demand for peak regulation increases. In view of the increasing pressure of environmental protection, the state has increased its efforts to develop new energy power generation. It is expected that China's energy cleaning rate will reach 50% in 2050. Large scale new energy units occupy the space of conventional power units, resulting in serious shortage of peak shaving capacity of receiving power grid [1]. The rapid development of new energy units in some regions and the particularity of new energy unit power generation, especially wind power generation has the "inverse peak regulation characteristics" of continuous fluctuation within a certain range during the day, gradual increase of wind power output at night, the highest average output in winter and the lowest average force in summer. This inverse peak regulation characteristic will aggravate the peak regulation pressure of the system with wind power grid connection, and the demand for peak shaving capacity of the system is greater, which brings greater challenges to power grid peak shaving [2, 3].

At present, the peak shaving of power grid mainly depends on thermal power units. In northern China, the proportion of thermal power units accounts for more than 50%. In the heating season, the units should give priority to meeting the heat load demand. There is a working condition constraint of "determining electricity by heat", and the peak shaving capacity is greatly reduced [4]. In the past, thermoelectric units rarely participated in peak shaving, but with the large number of new energy connected to the grid, the demand for peak shaving of power grid is increasing. Relying solely on pure condensing units can not meet the demand, and thermoelectric units must also participate in peak shaving [5].

Different from pure condensing unit, the peak shaving capacity of thermoelectric unit is not a fixed value, but changes dynamically with steam extraction. The heating and steam extraction capacity of the unit changes with the weather conditions, and the upper and lower limits of peak shaving also change [6]. In view of the shortcomings of the above existing technologies, this paper proposes an on-line monitoring method for the peak shaving capacity of thermoelectric units, which can realize the on-line monitoring of thermoelectric units, calculate the peak shaving upper and lower limits of thermoelectric units under different air extraction, evaluate the peak shaving capacity of thermoelectric units on-line, and provide reliable data support for the scientific dispatching of power grid.

2. Innovative on-line monitoring method of peak shaving capacity of thermoelectric units

The on-line monitoring method of peak shaving capacity of thermoelectric units proposed in this paper includes four steps: one is to upload the real-time heating extraction capacity of the monitored units; the other is to find the maximum power and minimum power corresponding to the heating extraction capacity according to the heating working condition diagram; the third is to calculate the maximum power or minimum power that can be generated by the monitored thermal power unit under the real-time heating extraction capacity according to the formula, that is, the upper or lower limit of peak shaving. Fourth, data such as real-time heating extraction volume and calculated power value are uploaded to the system and displayed.

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2.1 Upload real-time heating and steam extraction capacity of thermal power unit

Through the dedicated optical fiber channel of the power system, the real-time heat supply steam extraction and active power data in the DCS system of the monitored thermoelectric unit are uploaded to the database of the main monitoring equipment, and the real-time data is collected from the server of the main monitoring device and calculated for two times. Table 1 shows the real-time heating and steam extraction capacity transmitted to the main monitoring equipment server in a certain period of time.

Table 1. Real time heating steam extraction capacity.

Real time heating steam extraction t/h				
68.4	90.7	105.7	105.7	140.6

2.2 Find the power corresponding to the heating extraction volume according to the heating working condition diagram

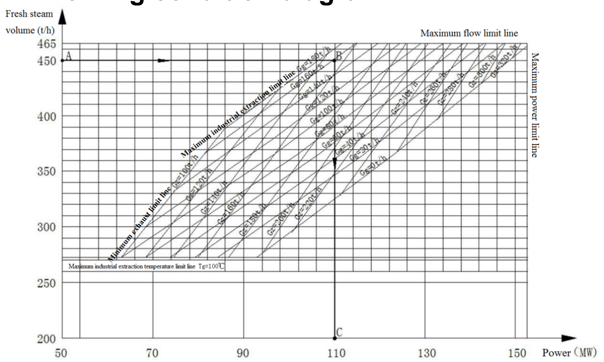

Figure 1. Structural diagram of steam feed pump system

Taking a 135MW Steam Extraction Unit of a thermal power Co., Ltd. as an example, the unit meets the operating conditions of the calculation conditions, and the design heating condition diagram of the steam turbine of the monitored thermal power unit is shown in Figure 1.

In Figure 1, G_Z is the exhaust steam volume of LP cylinder and G_g is the extraction steam volume. Main steam pressure $P_0 = 13.24$ MPa, main steam temperature $T_0 = 535$ ℃, extraction pressure $P_g = 0.981$ MPa, reheat steam temperature $T_r = 535$ ℃. In Figure 1, another parameter can be found according to any two of the three parameters: fresh steam volume, industrial extraction volume and power. For example, it is known that the fresh steam volume is 450 t/h (point A) and the industrial extraction volume is 160 t/h. in Figure 1, the horizontal line passing through point A intersects with the industrial extraction volume line of 160 t/h, and the intersection point is point B. Point C is obtained by crossing point B vertically downward and intersecting the power axis. The value of point C is 110.1mw, which is the checked power.

From the steam turbine design heating working condition diagram of the monitored thermal power unit in Figure 1, there are 10 equal extraction steam lines of 0 to 180 t/h respectively. The maximum power or minimum power corresponding to 10 groups of heating steam extraction of the monitored thermal power unit can be checked from 10 equal steam extraction lines, as shown in Table 2. Input 10 groups of the heating steam extraction volume and the corresponding maximum power or minimum power into the real-time calculation database.

Table 2. The maximum power and minimum power corresponding to the heating steam extraction volume obtained from Figure 1.

Heating extraction capacity t/h	0	20	40	60	80	100	120	140	160	180
Maximum power MW	152.7	147.4	143.1	138.6	133.9	129.1	124.7	119.7	114	111.6
Minimum power MW	92.8	84.4	79.1	73.9	68.4	59.4	68.6	75	81.6	85.7

2.3 Calculate the power (upper and lower limits of peak shaving) of the monitored thermal power unit under real-time heating steam extraction according to the formula

Adjust the real-time heating extraction volume, judge that the real-time heating extraction volume is between the heating extraction volume of group i and group i+1, and take the maximum power or minimum power corresponding to the heating extraction volume of group i and group i+1 as the calculation interval, where i= 1, 2,... 9. The linear interpolation method is used to calculate the maximum power or minimum power that can be generated by the monitored thermal power unit under the real-time heating extraction capacity, that is, the upper limit or lower limit of peak shaving under the real-time heating extraction capacity of the monitored thermal power unit.

The calculation formula of maximum power or minimum power that can be generated by the monitored thermal power unit under real-time heating and steam extraction is shown in (2-1).

$$P = P_i + \frac{P_{i+1} - P_i}{Q_{i+1} - Q_i}(Q - Q_i) \quad (1)$$

Wheres: Q -real time heating and steam extraction capacity of monitored thermal power unit, t/h ; $Q_i (i = 1,2,...9)$ -the steam extraction capacity of group i in the design heating working condition diagram of the monitored thermal power unit, t/h ; P -maximum power or minimum power corresponding to real-time heating and steam extraction of monitored thermal power unit, MW ; $P_i (i = 1,2,...9)$ -the maximum power or minimum power corresponding to the heating extraction capacity of group I in the design heating working condition diagram of the monitored thermal power unit, MW .

According to formula (2-1), the upper or lower limit of peak shaving under the real-time heating and steam extraction capacity of the monitored thermal power unit is obtained from the real-time heating and steam extraction capacity uploaded in Table 1, as shown in Table 3.

Table 3. Upper or lower limit of peak shaving under real-time heating extraction capacity.

Real time steam extraction t/h	68.4	90.7	105.7	105.7	140.6
Maximum power(Peak-shaving upper limit) MW	136.7	131.3	127.8	127.8	119.5
Minimum power (Peak-shaving lower limit) MW	71.6	64.0	60.2	60.2	75.2

2.4 Upload data for system display

The above real-time heating steam extraction volume, active power and the calculated peak shaving upper or lower limit are output to the man-machine interface for display, so as to complete the on-line monitoring process of peak shaving capacity of thermal power units to be monitored. The dispatcher can monitor the upper limit or lower limit of peak shaving of the monitored thermal power unit under the real-time heating extraction capacity in real time from the man-machine interface.

Compared with the traditional calculation methods, the on-line monitoring method proposed in this paper has obvious advantages: for example, it can monitor multiple groups of thermal power units in various regions at the same time, with large monitoring intensity and wide range, which provides important data support for multiple groups of thermal power units in various regions at the same time; Transmitting real-time data to the server of the main monitoring equipment through special optical fiber channel can not only make full use of the resources of the power system, but also increase the reliability of data transmission; The linear interpolation method is simple, convenient and fast.

3. Conclusion

This paper presents an on-line monitoring method of thermoelectric units. By uploading the real-time data in the DCS system of the monitored thermal power unit to the main monitoring equipment, find multiple groups of heating extraction capacity and the corresponding maximum power or minimum power from the design heating working condition diagram of the monitored thermal power unit, and use the actual calculation database in the main monitoring equipment to calculate the maximum power or minimum power of the monitored thermal power unit under the real-time heating extraction capacity in the background, then output it to the human-machine interface for the reference of the power supply network dispatcher, so as to provide reliable data support for the scientific dispatching of the power grid. This method can monitor the peak shaving upper and lower limits of thermoelectric units under different real-time heating steam extraction in the heating season, and provide important data support for the power grid dispatching department to scientifically and reasonably formulate the load dispatching curve of thermoelectric units.

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