

# Research and Application of Coal Blockage Early Warning Judgment in Coal Pulverizing System of Thermal Power Generating Units

Junyu Cai<sup>id</sup>, Weiwen Chen, Delei Wang, Ning Ding, Jiangfeng Zhang, Libin Dong, Xinsheng Zhang, and Pingping Cai

**Abstract**—This paper introduces the mechanism-based fault diagnosis model of the main equipment of the milling system, and adopts the trend state detection and failure mode recognition methods according to the detection data for comprehensive diagnosis. The experimental results show that it can effectively detect the coal blocking and coal breaking faults of the coal feeder and the coal mill, effectively reduce the system false alarm rate, accurately capture the abnormal moment of the indicator, and relatively manual observation is a little early, ensuring the stable operation of the milling system, reducing the workload of the operating personnel and improving the safety and economy of the unit.

**Index Terms**—Generator set, coal pulverizing system, plugging coal, early warning judgment.

## I. INTRODUCTION

AT PRESENT, thermal power generation is still the main electric energy production methods in China. Generation units convert the chemical energy of pulverized coal into thermal energy by combustion, and work on the steam turbine to realize the conversion of heat energy to electric energy. And the coal pulverizing system in the thermal power plant is responsible for making the raw coal into qualified pulverized coal, and the specific process is to send the raw coal into the coal mill after the raw coal hopper and the coal feeder in the boiler coal pulverizing system, grind it into powder in the coal mill, and finally send it to the pulverized coal warehouse, or directly into the boiler for combustion.

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Junyu Cai is with the Electric Power Research Institute, State Grid Zhejiang Electric Power Company Ltd., Hangzhou 310014, China, and also with the Instrument and Control Office, E. Energy Technology Company Ltd., Hangzhou 310014, China (e-mail: caijunyu888@163.com).

Weiwen Chen and Pingping Cai are with the Instrument and Control Office, E. Energy Technology Company Ltd., Hangzhou 310014, China (e-mail: 526589111@qq.com; 18332002@qq.com).

Delei Wang is with the Innovation Research Institute, Zhejiang SUPCON Technology Company Ltd., Hangzhou 310053, China (e-mail: wangdelei@supcon.com).

Ning Ding, Jiangfeng Zhang, and Xinsheng Zhang are with the Electric Power Research Institute, State Grid Zhejiang Electric Power Company Ltd., Hangzhou 310014, China (e-mail: dingningcss@163.com; zhangjiangfeng0725@163.com; 1271904927@qq.com).

Libin Dong is with the Instrument and Control Office, Zhejiang Datang Wushashan Power Generation Company Ltd., Ningbo 315722, China (e-mail: donglibinix@126.com).

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The coal pulverizing system is an important auxiliary system for coal-fired units. Its role is to grind qualified pulverized coal to ensure the need for boiler combustion. Its operation quality will directly affect the safety and economy of the boiler. Due to the complex technological process, poor production environment, complex and changeable working conditions of the coal pulverizing system, the coal feeder and the coal mill run at a continuous high load for a long time will lead to various failures in the coal pulverizing system, and a large number of operators and maintenance personnel are required to analyze and solve these problems to ensure the long-term stable operation of the units.

The combustion control system is the direct execution stage of the boiler side of the coordination control system and is the main control system of the unit [1]. For thermal power generation units, the stability of their coal pulverizing systems directly affects the safe operation of units, especially for the DC furnaces of supercritical units, which is particularly important. Analysis from the coordination control logic, most of the generator sets use the fuel amount as the baseline control mode, which is, when the fuel master control is manual, the boiler master control tracks the actual amount of fuel corresponding to the coal amount of the reference line, no matter what kinds of coordinated control strategies, the boiler master control will be the top priority, the quality of the boiler master control adjustment is directly related to the entire coordinated control system, the main system of water supply, fuel master control, total air volume control and other major systems accept the boiler master control instructions, related to all aspects of the boiler. At the same time, in order to effectively reduce the cost of power generation, more and more power plants choose coal-fired combustion to control power generation costs. However, the mixing of inferior coal, because the coal contains mud and water, it is very easy to block the coal pipe that falls on the coal machine, resulting in the coal machine breaking the coal [2]. Literature 3, Literature 4 and Literature 5 respectively introduced that after the coal blockage occurred in the three major devices of the coal machine, the falling coal pipe and the coal mill, the units trip was caused by the inaccurate judgment of the operator on the coal blocking site and the untimely disposal.

Therefore, through advanced technical means, monitor and analysis of equipment status parameters, and realizing the automation of fault diagnosis and prediction are the inevitable

requirements to ensure the safe and reliable operation of the coal pulverizing system and improve the safety and economy of the thermal power generation system.

## II. RESEARCH STATUS OF COAL PLUGGING FAULT DIAGNOSIS IN COAL PULVERIZING SYSTEMS

The coal pulverizing system is a complex control object with a high incidence of failure. The following failure characteristics are summarized in [6]: (1) The relationship between each fault indication is quite complicated, which shows its strong coupling and nonlinear characteristics; (2) Due to the complex operating environment of the coal pulverizing system, its failures shows uncertainty, that is, there is a complex mapping relationships of “one-to-many” and “many-to-one” between the fault indications and the fault types, and the above characteristics bring difficulties to the realization of the fault diagnosis of coal pulverizing systems.

Although the current academic researches on the fault diagnosis of coal pulverizing systems has achieved certain results, only a few scholars have conducted relevant researches. For example, the fuzzy algorithm was to establish a fault diagnosis and prediction system for shearers, which can accurately predict the pressure value of the hydraulic system [7]. Fault diagnosis of TE process based on residual weighting method of T-S fuzzy model, with an accuracy rate of more than 96% was proposed in [8]. An ash box model of a medium-speed coal mill based on genetic algorithms was established, and the accuracy rate of single-point fault identification has reached more than 90% [9]. The fuzzy cluster analysis (FCM) method based on D-S evidence theory proposed in [10], which can effectively solve the ambiguity of mill failure and realize the prediction of coal mill failure through quantitative analysis. The multi-sensor information fusion technology was applied to the state monitoring and fault diagnosis system of the coal mill can make the diagnosis results more accurate and reliable, and greatly reduce the cost of the equipment condition monitoring and fault diagnosis system [11]. Other more commonly used fault diagnosis methods include diagnostic theories and methods based on mechanism research, vibration signal diagnosis methods, fault tree analysis diagnosis methods, neural network fault diagnosis methods, etc. [12], [13], but there are more or less disadvantages such as great dependence on typical samples, long time-consuming model diagnosis, biased conclusions such as overlapping test samples and training samples, there are certain limitations, huge research space and many problems that need to be solved urgently.

## III. DESIGN IDEAS

Utilizing the existing signal measurement points of DCS, three main devices involved in the coal pulverizing system are classified, namely the coal feeder, the falling coal pipe and the coal mill, and the coal feeder fault, the coal feeder outlet falling coal pipe plugging fault and the coal grinder plugging fault model are designed, and through the change trend of relevant parameters [13], [14], the fault probability value of the corresponding part of the coal blocking can be quickly

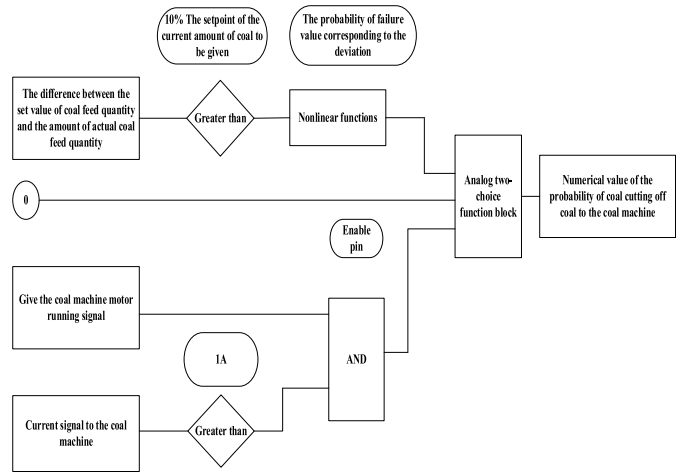


Fig. 1. Coal feeder fault control strategy.

and accurately given, and the efficiency of coal plugging is improved.

### A. Coal Feeder Breakage Fault

Signals such as the operation feedback of the coal machine, the current signal of the coal machine, the given instruction of the coal machine, the actual amount of coal, are selected. Take that the coal feeder operation feedback and the current signal is greater than 1A as the state judgment of the coal feeder operation. The signal is used as an enable pin, and when the enable signal is triggered, it activates the numerical judgment function of the possibility of breaking to the coal machine. If the difference between the instruction of the coal feeder and the actual coal feeding amount is more than 10% of the set value of the coal feeding amount, which lasts for 3s, it can be judged that the coal feeder will have a coal break fault. Then according to the size of the deviation and the deviation time, the failure possibility of the coal feeder is given through a nonlinear function. The specific control strategy is shown in Fig. 1.

### B. Coal Fault Plugging in the Falling Coal Pipe at the Outlet of the Coal Machine

Signals such as the actual amount of coal fed by the coal feeder, the current signal of the coal feeder, the signal of the coal feeder breaking coal, the current signal of the coal mill, the actual value of the outlet temperature of the coal mill, the set value of the outlet temperature of the coal mill, are selected. The trend of the current of the coal mill, the actual coal amount of the coal feeder and the temperature control deviation of the outlet of the coal mill, combined with the fault signal of the coal feeder are used. When the coal machine does not appear to break the coal signal, the actual amount of coal given to the coal machine does not show a downward trend. However, after the current of the coal mill continues to drop for 20 seconds, the actual value of the outlet temperature of the coal mill minus the difference in the set value rises. It can be judged that the coal blocking failure will occur in the coal outlet falling pipe of the coal machine. And according to the

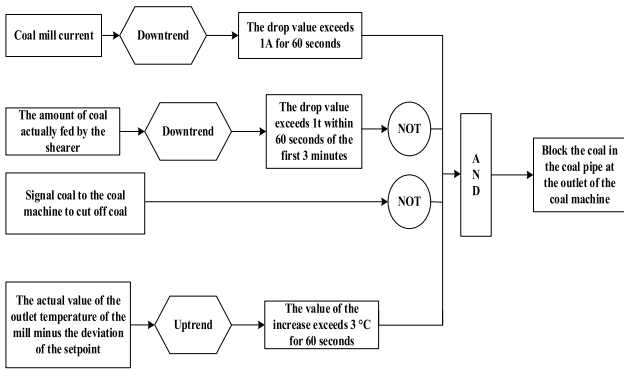


Fig. 2. Coal blocking control strategy for falling coal pipe at the outlet of coal machine.

size and deviation time of the outlet temperature difference of the coal mill, the failure possibility of the coal blocking of the coal falling pipe at the outlet of the coal mill is given through the nonlinear function. The specific control strategy is shown in Fig. 2.

C. Coal Mill Plugging Coal Fault

Signals such as the differential pressure of the inlet and outlet of the coal mill, the outlet temperature of the coal mill, the opening of the cold/hot air duct of the coal mill, the primary air flow of the coal mill, the current signal of the coal mill, the actual amount of coal fed by the coal feeder, are selected. By characterizing the current of the coal mill and the actual coal supply operating state of the coal feeder, and in the case that the coal feeder is not broken, when the actual coal mill outlet temperature and the coal mill outlet temperature set value deviate and are greater than the judgment reference value, and the current of the coal mill drops and the actual coal feeder drops, it can be judged that the coal mill will have a coal break fault. And according to the weighted calculation of the change trend of the inlet and outlet differential pressure, outlet temperature, and primary wind flow, the failure possibility of the coal mill breaking is given through a nonlinear function. The specific control strategy is shown in Fig. 3.

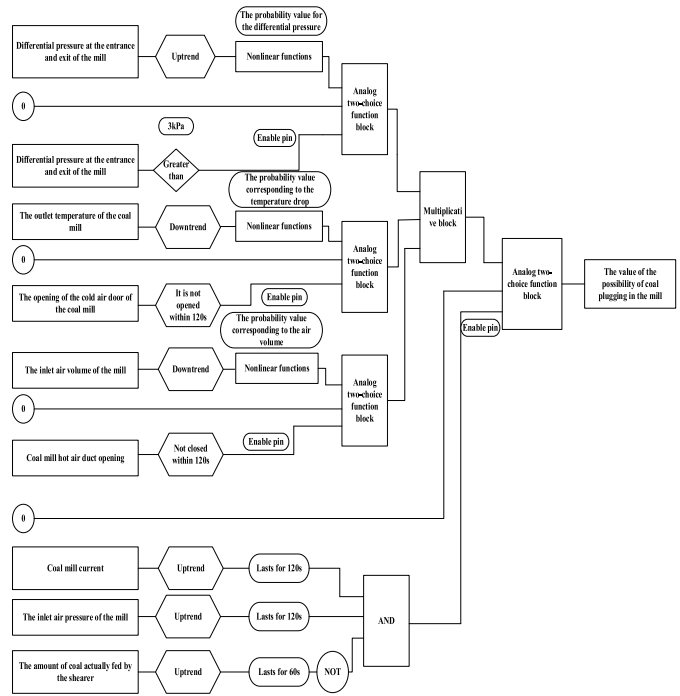


Fig. 3. Coal mill plugging fault control strategy.

TABLE I  
MAIN PARAMETERS OF COAL MILL AND COAL FEEDER

Device	Parameter
Coal mill	the differential pressure between the upper and lower parts of the mill bowl
	the inlet air pressure
	The actual outlet temperature
	The opening of the cold primary damper
	the inlet air volume
	the opening of the hot primary damper
	the current
Coal feeder	the operating state of the motor
	the current
	The set value of the coal amount
	The actual value of the amount of coal

IV. DATA ANALYSIS AND IMPLEMENTATION EFFECTS

A. Data Analysis

A power plant has a total of six coal mills and six coal feeders, and the main parameters of each device are shown in Table I.

The data from 05/11/2022 to 05/14/2022 in the on-site SIS system are extracted and analyzed. There are 121 parameters in total, and the original data are filled in seconds by linear interpolation.

B. Implementation Effects

a) Coal fault test for coal cutter: The operator usually determines whether the device has a coal failure by observing the curve deviation of the set value and the actual value of the coal feeder. Fig. 4 marks the point where the coal feeder F may fail on the test data set, marking a total of 8 time periods

that there may be a coal break fault. The subsequent display data are displayed in the set value and the actual value.

According to the fault judgment model in 3.1, the coal feeder F was diagnosed, and 2 time periods for which abnormalities might occur were detected, of which red was marked as the detection of coal breakage points.

In Fig. 5, red curve show the anomaly detection point: the first abnormal period is 5/13/2022 18:04:30 ~ 5/13/2022 18:05:22; the second abnormal period is 5/14/2022 12:27:10 ~ 5/14/2022 12:28:11. The coal volume change is shown in Fig. 6 and 7, of which the red curves show the marked detection breakage point:

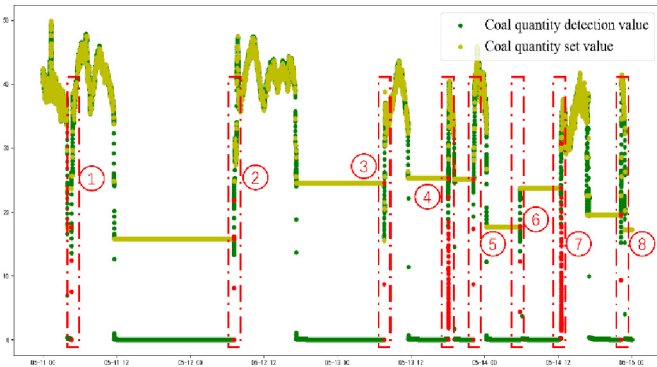


Fig. 4. The possible coal break moment of coal feeder F.

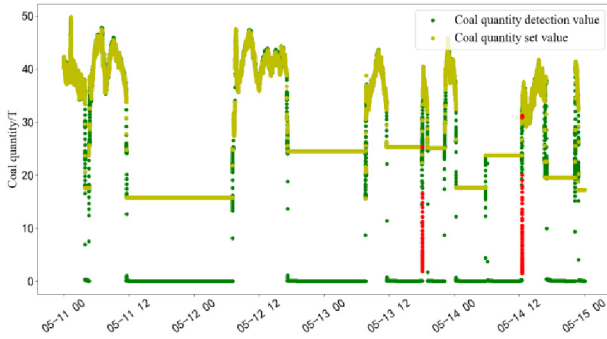


Fig. 5. The fault diagnosis results of coal feeder F.

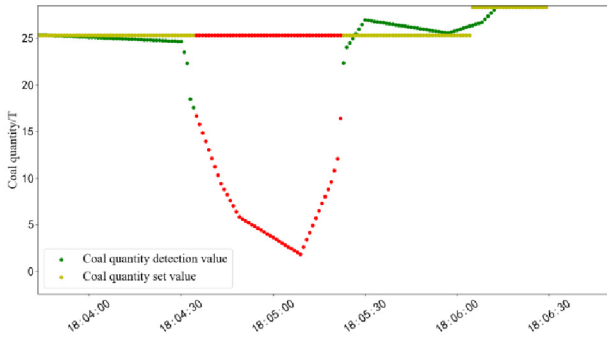


Fig. 6. The first detected point of failure.

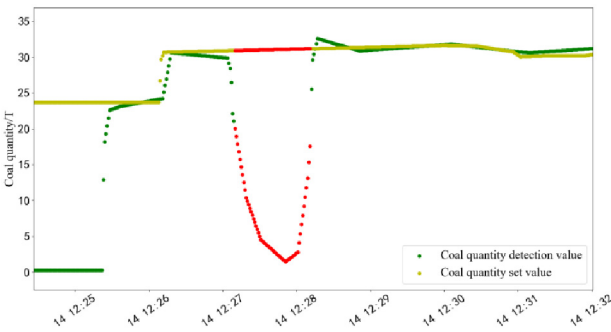


Fig. 7. The second detected point of failure.

After the confirmation of the on-site operators, the model detected the coal fault and the actual reported fault was the same, and the time was more than half a minute earlier than the time when the operator found the record.

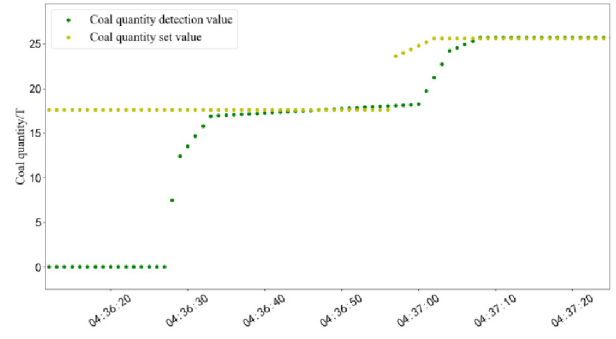


Fig. 8. Unreported possible coal break point 1.

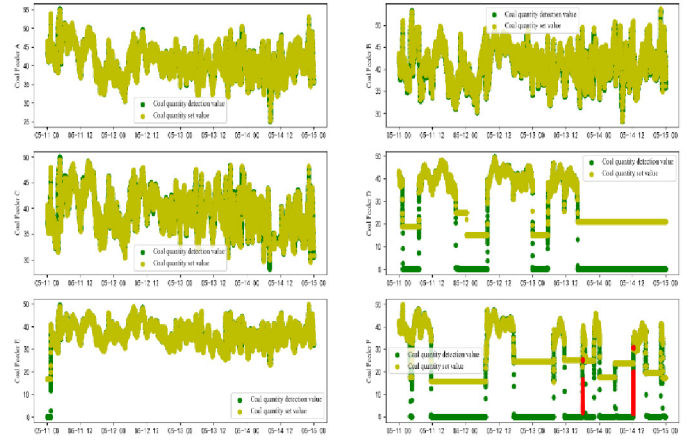


Fig. 9. The fault diagnosis results of coal feeder A-F.

In Fig. 8, it can be observed that when the coal amount set point raises or the coal feeder starts up, if the actual value of the coal volume cannot be followed for a short time, the fault will occur. Points 2, 3, 5, 7 and 8 in Fig. 8 are all such cases.

Additional diagnosis of coal feeder are inspected, as shown in Fig. 9:

The figure shows that the coal feeder A-E have not detected any abnormalities, and there is no actual failure at the scene, F is the two sections of coal breakage analyzed by the above detection.

b) *Coal plugging fault experiment for coal pipe drop to coal machine:* The occurrence of coal blocking incidents in the falling coal pipe is less frequent, and the data is extracted from the on-site SIS system for analysis for a longer period of time, and the data of the time period is: 5/1/2022 ~ 5/31/2022, and the original data is filled by seconds in a linear interpolation manner.

According to the fault judgment model in 3.1, the coal feeder A-F are diagnosed, as shown in the Fig. 10.

For up to a month, no coal blockage incidents were reported in the falling coal pipe, and there was no feedback on the scene of the coal blockage incidents, and there was no false alarm problem.

## V. CONCLUSION

The results show that the control strategy and implementation method proposed in this paper are more comprehensive and flexible, and the fault identification types can be expanded

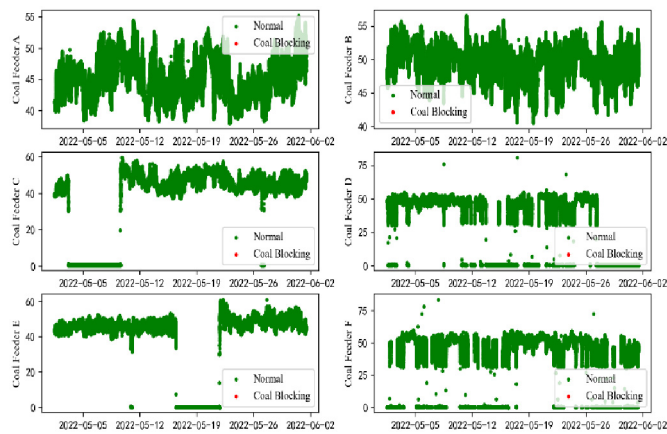


Fig. 10. The diagnostic results of coal feeder A-F.

compared with other diagnostic methods, the diagnosis time is shorter, and the diagnostic accuracy is higher. The research results have reference significance for the application of hybrid intelligent algorithm in fault diagnosis, and have practical significance for the construction of online fault diagnosis system for power plant coal pulverizing system.

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**Junyu Cai** was born in Tianjin in 1990. He graduated in control theory and control engineering from the University of Chinese Academy of Sciences in 2016. He is currently working with the State Grid Zhejiang Electric Power Research Institute. His research direction is the application research of artificial intelligence technology in the electric power field, including the application of natural language processing technology and knowledge atlas in the electric power intelligent question answering system, the application of natural language processing technology in the document query system, the remote expert center in the electric power field, the application of robot technology in the electric power patrol field, and the application of unmanned aerial vehicle technology in the electric power patrol field.



**Weiwen Chen** received the bachelor's degree in measurement and control technology and instrument engineering from China Jiliang University, Hangzhou, China, in 2010, and the master's degree in control engineering from Polytechnic Institute, Zhejiang University, Hangzhou, in 2020. He mainly engaged in coordinated control of power plant units.



**Delei Wang** received the bachelor's degree in computer science and technology from Shandong University. He is with Zhejiang SUPCON Technology Company Ltd., engaged in work related to artificial intelligence.



**Ning Ding** received the master's degree from North China Electric Power University in 2012. He Worked with State Grid Zhejiang Electric Power Research Institute. His research interests includes intelligent control of power plant and virtual power plant technology research.



**Jiangfeng Zhang** received the master's degree from Zhejiang University in 2013. He was a Senior Engineer with State Grid Zhejiang Electric Power Research Institute. His research interest covers pattern recognition and power system grid source coordinated control technology.



**Libin Dong** worked with the Equipment Department, Zhejiang Datang Wushashan Power Generation Company Ltd., after graduation in 2009, and has been engaged in technical transformation of thermal control, standard preparation, smart enterprise construction and other related work. He has successively served as the Foreman of the Thermal Furnace Team, the Thermal Engineer, the Deputy Director of Thermal Control, and the Director of Dong Libin Innovation Studio.

As the person in charge of the innovation studio and the company's technical experts, he actively undertook the company's innovation work. This year, he completed the Pilot Project of enterprise intelligent construction, participated in the preparation of one international standard and one national standard, and won four awards for scientific and technological achievements and two awards for scientific and technological papers.



**Pingping Cai** received the bachelor's degree in human resource management from Peking University. She is with Hangzhou Yineng Power Technology Company Ltd. Her research is mainly responsible for administrative management and DCS performance test research.



**Xinsheng Zhang** received the master's degree in control engineering from North China Electric Power University. He is with State Grid Zhejiang Electric Power Research Institute. His research is mainly responsible for capital construction and commissioning of large coal-fired units, control system optimization, and application research of automatic startup and shutdown technology of coal-fired units in thermal power generation units.